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Hon. W. J. ASSELSTINE, *Minister* JOHN F. WALKER, *Deputy Minister*

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Fraser River Tertiary Drainage-history in relation to Placer-gold Deposits

(PART II.)

by

DOUGLAS LAY

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FRASER RIVER TERTIARY DRAINAGE HISTORY

IN RELATION TO

PLACER-GOLD DEPOSITS

(Part II)

INTRODUCTION

This report supplements British Columbia Department of Mines Bulletin No. 3, 1940, and continues the investigation of the Fraser River drainage as far as the Grand Canyon, 109 miles up-stream from Prince George. The river, confined for 120 miles up-stream from this point, emerges from the Rocky Mountain Trench through a wide local break in the north-westerly continuity of that great valley.

Reference is invited to British Columbia Department of Mines Bulletin No. 3, 1940, for much preliminary information which is not repeated in this report.

For convenience the terms used to designate the Fraser River at different periods in its history, given on page 2 of Bulletin No. 3, 1940, are repeated here. The terms "pre" and "inter" are used in the ordinary geologic sense. The term "pre-volcanic Fraser River" designates the river antedating the volcanism expressed by the Lower Lavas. The term "inter-volcanic Fraser River" is applied to the river flowing between the two periods of volcanism expressed respectively by the Lower Lavas and the Upper Volcanics. The term "intra-Lower Lavas Fraser River" is applied to the river flowing during or before actual cessation of volcanism expressed by the Lower Lavas. The term "intra-Upper Volcanics Fraser River" is applied to the river flowing during or before actual cessation of the volcanism expressed by the Upper Volcanics. Exposures of sediments of the last-mentioned were found during the field work of 1940.

To facilitate examination of all rock-outcrops on both banks of the Fraser River, investigation during 1940 was made by outboard-engined motor-boat, between Macalister and the Grand Canyon. The McGregor River and Herrick Creek were ascended as far as the junction of Fontoniko Creek with the latter. Where deemed necessary mountains adjacent to the river were examined, and after completion of reconnaissance by boat, regions more remote from the Fraser River adjacent to its large tributary, the Nechako River, were explored.

Although this report does not deal with the Pleistocene drainage-history of the Fraser River, it was found necessary to devote some time to study of Pleistocene features to decipher Tertiary drainage-history.

Most elevations mentioned were determined by altimeter, the instrument being checked as frequently as practicable by comparison with Geodetic Survey monuments at Prince George, Strathnaver and Quesnel. In some cases the context renders clear that elevations given are those determined by the Department of Lands.

It is desired to tender thanks to C. C. Kelly of the British Columbia Department of Agriculture, in charge of the soil survey of a large area centering in Prince George, for kind assistance extended in various ways.

Thanks are also due H. Hobe and M. Framstat for timely and invaluable assistance in navigating the difficult waters of Herrick Creek.

Assistance in the field was rendered by Alan R. Smith and Lorne E. Rowebottom.

SUMMARY

A summary of the more important facts ascertained in the course of field work during 1940 is given below. Details follow in the body of the report.

(1) On the east bank of the Fraser River, somewhat over 3 miles north of Shelley, exposures of sediments (conglomerate and sandstone) of the pre-volcanic Fraser River, occur in the Canadian National Railway-cutting and extend below river-level. No fossils were found in these sediments and the state of preservation of silicified driftwood proved too poor for identification. The high degree of lithification of the sediments suggests that their age is early Eocene or possibly even late Cretaceous. This exposure is deemed of high critical value as it proves not only the far northern early deep incision accomplished by the pre-volcanic Fraser River, but also the exact position of the river at that time.

(2) This examination disclosed a wide break in the Rocky Mountain Trench near the Grand Canyon. At this point the southern wall of the Trench ends abruptly, while the northern wall continues but a few miles farther to terminate near Sinclair Mills at the great gap about 12 miles wide, caused by the junction of the McGregor River Valley with the Fraser River Valley. This break in the continuity of the Rocky Mountain Trench continues until it is restored to normal proportions at the junction of the valleys of the Pack and Parsnip Rivers, from whence it continues north-westerly for many miles. After flowing confined within the Rocky Mountain Trench for 120 miles, the Fraser River emerges from it just above the Grand Canyon, and then flows over the eastern edge of the Nechako Plateau. The river makes a bend at its most northerly point by reason of the surrounding structural features. The Arctic-Pacific Divide, but a few miles west of the McGregor River Valley, trends directly across the direction of flow of the river up to this point, and it is apparent that at no time in its history can the Fraser River have continued to flow in a north-westerly direction past the mouth of the McGregor River. It is, however, quite possible that there has been a reversal of flow of the waters in that part of the Fraser River down-stream from the mouth of the McGregor River, as suggested in (4) below.

(3) In the course of this examination, an intrusive tongue of diorite was discovered at the north-western end of the Bearpaw Mountains, north-east of Sinclair Mills (Fig. 3). This range of mountains here forms the northern wall of the Rocky Mountain Trench, the north-westerly continuity of which is at this point interrupted by a wide break as mentioned in (2) above. The occurrence of intrusive rocks in the northern wall of the Rocky Mountain Trench and north of Eaglet Lake indicates the far eastward extent

of the effects of the Jura-Cretaceous revolution. The presence of intrusive rocks at these points, also suggests the likelihood that the Rocky Mountain Trench and some parallel trenches in this region were developed prior to the Laramide revolution and gradual uplift of the Rocky Mountains. Pronounced trellis-type drainage is exhibited locally to the south-east of the McGregor River (Fig. 3).

(4) The evidence obtained suggests that drainage in the south-westerly flowing parts of Herrick Creek and the McGregor River has been reversed (these waters are virtually one and the same stream occupying the same valley, and are referred to in this report as the "Herrick-McGregor" River). In late Cretaceous time, possibly extending to early Tertiary time, these waters were likely the headwaters of the Murray River, then flowing north-easterly through the site of the Monkman Pass in the Rocky Mountains. Quite possibly the Fraser River at the great bend at its most northerly point now occupies the deepened bed of a former tributary of the Herrick-McGregor River, then flowing in the opposite direction. Reversal of drainage was due to two causes: (a) Capture of its headwaters by the rapidly-rejuvenating southerly-flowing Fraser River (evidence cited in (1) above), which sapped the power of the Herrick-McGregor River to maintain its flow, as did the Peace River, against (b) the slow upheaval of the Rocky Mountains during the Laramide revolution in early Tertiary time.

(5) Supported by strong although indirect evidence, it is postulated that in late Cretaceous time the ancestral Fraser River drainage was northerly. Whether this drainage was mainly by the Peace River and partly by the Herrick-McGregor River, or partly by the Peace River and mainly by the Herrick-McGregor is conjectural, but the result of this examination favours the adoption of the latter hypothesis.

(6) Reference (Fig. 2) will render clear that the Fraser River makes a wide detour to the west between Whites Landing and the mouth of the Cottonwood River. Exposures leave no doubt as to the reason. The pre-volcanic southerly-flowing Fraser River, intra-Lower Lavas Fraser River and the inter-volcanic Fraser River, occupied a valley trending almost due south between Whites Landing and the mouth of the Cottonwood River, the approximate position of which is indicated (Fig. 1 British Columbia Department of Mines Bulletin No. 3, 1940). This valley is now largely filled except at its north-western extremity where it is occupied by the northerly-flowing part of Canyon Creek. The western rock-rim of this valley is the rocky region west of Whiteslanding Creek, and the eastern rock-rim is exposed on Government, Hixon, Terry and Ahbau Creeks, and on the Cottonwood River at the highway crossing. Prior to the inter-volcanic Fraser River, the waters occupied the eastern part of this valley. From exposures of Australian members (a) of the Fraser River formation, and of sediments of the pre-

volcanic southerly-flowing Fraser River on Canyon Creek, it is believed that the accumulation of sediments in the eastern part of the valley caused the inter-volcanic Fraser River to shift to the western part of this valley. Exposures also demonstrate conclusively that up to this time the West Road (Blackwater) River joined the Fraser River at Whites Landing, and that that part of the present Fraser River Valley between the mouth of the West Road River and the mouth of the Cottonwood River was not then in existence. When the Fraser River was subsequently dammed at downstream points by the Upper Volcanics, it abandoned its ancient valley in this region which was largely filled with an immense accumulation of sediments. A new valley was incised between the former mouth of the West Road River (half a mile above the present mouth of this river) and the mouth of the Cottonwood River, and drainage was reversed in the former north of its mouth. The Cottonwood Canyon is largely a post-glacial and Pleistocene feature, but the Tertiary Mine-Canyon Mine channel quite possibly represents the Tertiary cutting of the lower end of the detour.

(7) No evidence was found of damming of the Fraser River by either Lower Lavas or Upper Volcanics up-stream from Quesnel. On the other hand there is very conclusive evidence of the damming of the Nechako River and its tributary, the Chilako River, by the Lower Lavas. If these last two rivers were dammed by the Upper Volcanics no evidence of it was found.

(8) During 1940, large exposures of sediments of the Fraser River dammed by the Upper Volcanics were found (to which the term "intra-Upper Volcanics Fraser River" is applied), near the top of the east rim of the Fraser River Valley near Macalister.

(9) Lacustrine deposits, believed to be of Tertiary age, were discovered at several points: west of the Fraser River near Prince George; on both banks of the Fraser River near the Junction of Tabor Creek, and on Government, Hixon and Terry Creeks. These deposits form a false bed-rock on which, in several instances, important concentrations of placer-gold are found.

(10) Commercial Possibilities

(a) The association of a concentration of placer-gold with the lacustrine deposit on the east side of the Fraser River near Tabor Creek, indicates the advisability of prospecting on the west side of the river in this region where a similar deposit exists. Unless post-glacial gravels directly overlie the latter there cannot, of course, be any placer concentration due to the excellent false bed-rock formed by the lacustrine deposit. This further condition must therefore be sought. Prospecting also seems merited on the east side of the river north and south of the points at which the lacustrine deposit is exposed.

It is a rational inference that there must be a concentration of placer-gold in the bed of the river where it cuts the deposit, but in view of the depth and velocity of the river, it seems unlikely that the gold can be profitably recovered.

(b) The exposures of compacted sediments of the Tertiary West Road River, and of the well-lithified sediments of the pre-volcanic Fraser River near Shelley, described in detail in the body of this report, are in both cases of considerable extent. The question arises as to whether commercial possibilities exist in either case. Recovery of bed-rock values could only be made by deep-lead mining methods, the cost of which even although no difficulties were encountered due to water or bad ground, would be unavoidably high. Unfortunately, moreover, important critical factors are entirely unknown, for example the depth to bed-rock, and the bed-rock values. In both cases bed-rock is below the level of the Fraser River. The values found in the Tertiary Mine (see Bulletin No. 3, 1940) might serve as an indication of what may be expected in the case of the Tertiary West Road River. In the case of the exposures of the sediments of the pre-volcanic Fraser River, near Shelley, it is even more difficult to form an opinion of bed-rock values. In this case all that can be said is that the river possibly eroded a quartz vein terrain up-stream at its most northerly point. The present outcrops of these veins are only slightly auriferous.

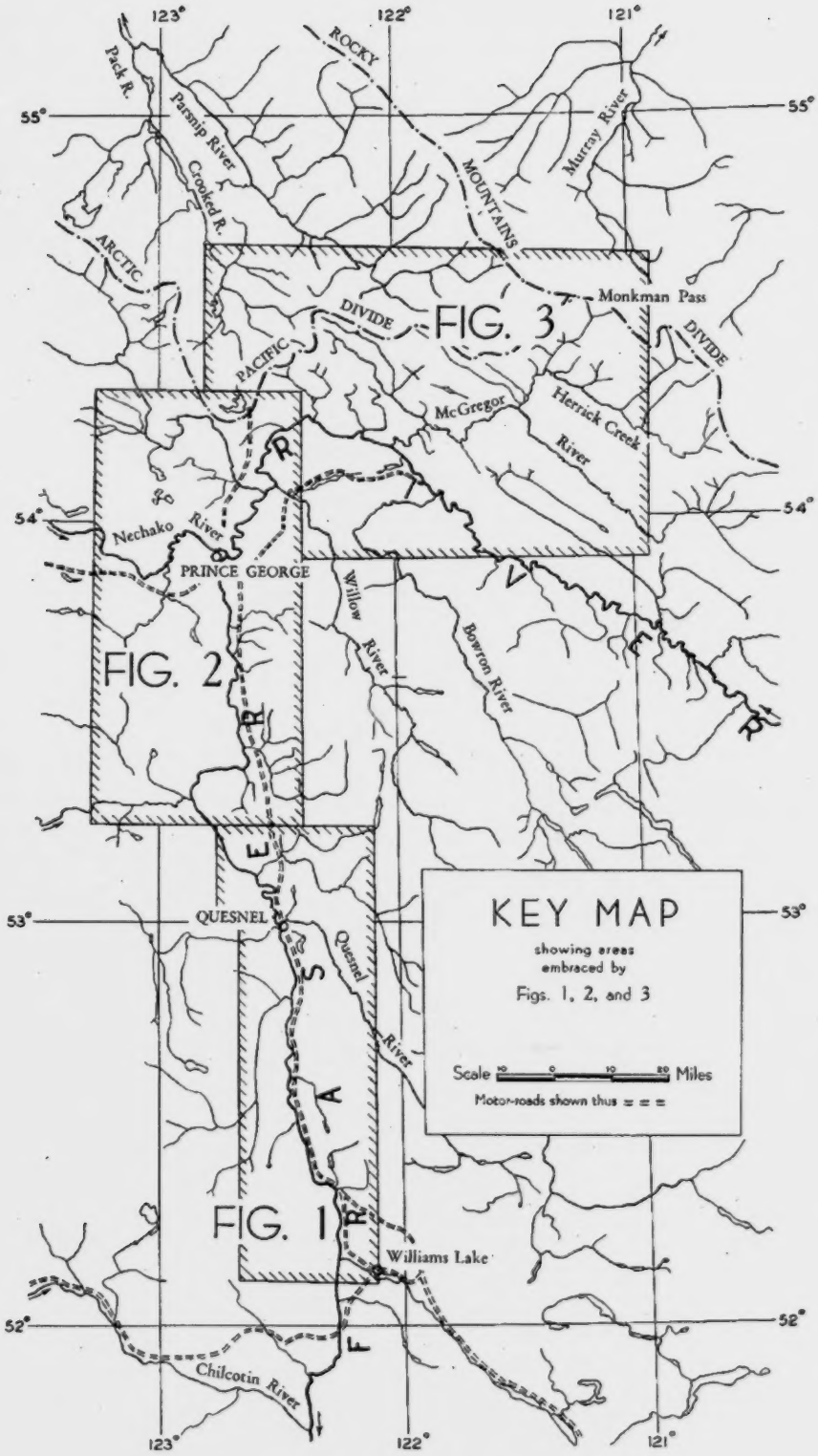
TOPOGRAPHY

Fraser River Valley

In its upper reaches the Fraser River enters the Rocky Mountain Trench by the Yellowhead Pass, a gap in the northern wall of the Trench opposite Tete Jaune. From this point the river flows north-westerly within the Rocky Mountain Trench in which it is imprisoned for a distance of 120 miles. Just above the Grand Canyon 109 miles up-stream from Prince George, the Rocky Mountain Trench ends abruptly but temporarily. The southern wall merges in the Nechako Plateau, at this point, while the northern wall terminates a few miles farther at the southwesterly-trending McGregor River Valley, which is about 12 miles wide at its accordant junction with the Fraser River Valley. Bearpaw Mountains, which here form the northern wall of the Rocky Mountain Trench, rise to a height of about 3,500 feet above the Fraser River, the elevation of the north-west end of this range being 5,557 feet.

The topography both to the north-east and to the south-west of the Fraser River in this region is noteworthy. There are six closely-spaced parallel northwesterly-trending mountain ranges to the south-west of the central ranges of the Rocky Mountains all of which terminate north-westerly at this point. These are, naming them from east to west, the Dazaiko Mountains, McGregor Mountains, Bearpaw Mountains, Cariboo Range (which forms the southern wall of the Rocky Mountain Trench, up-stream from the Grand Canyon), the unnamed range between the Bowron and Willow Rivers, and the unnamed range between the Willow and Fraser Rivers, at the north-western end of which is "Six Mile Mountain" to the east of Tabor Lake.

At the northern end of the last three mountain ranges is a large valley of mature relief about 20 miles in length which trends directly across the direction of the major axes of the ranges, between the south-westerly and north-westerly trending parts of the Fraser River Valley. In short it forms a more gradual bend of the Fraser River Valley than that occupied by the river at its most northerly point and is followed by both the Canadian National Railway and by the highway. This valley is largely unfilled and is occupied by Eaglet, Aleza and Hansard Lakes, the first-mentioned drains westerly into the Willow River, and the last two drain easterly into the Fraser River. The eastern end of this valley is almost opposite the McGregor River Valley and considerably north of the point at which the northern wall of the Rocky Mountain Trench ends (Fig. 3). There seems every reason to suppose that this valley, now abandoned, was once occupied for a lengthy period by a large stream of water. At its western end it commences somewhat abruptly as though rapidly eroded by a transverse watercourse, for example the Willow River which flows directly across



Key map showing location of Figures 1, 2 and 3.

the course of this valley near its mergence with the Fraser River Valley. On the other hand, the Bowron River, nearby, makes an abrupt easterly turn, flowing parallel to it until joining the Fraser River. Rock-rims about a quarter of a mile apart, rise some hundreds of feet above and on either side of Eaglet Lake.

The rise on the southern side of the lake is less sharp and the rim somewhat lower than on the north where it forms the southern slope of a mountain, elevation 3,117 feet, in the central part of which is a granite stock. Easterly, the height of both rims of this valley decrease towards mergence with the Fraser River Valley somewhat down-stream from Hansard Post Office. It is apparent that the bottom of this valley can be but little above that of the Fraser River near Hansard station, elevation 2,006 feet. As determined by altimeter on August 28th, the elevation of the Fraser River at the end of the motor-road near Hansard station was only 20 feet below the latter point. The elevation of Aleza Lake station is 2,007 feet, that of Giscome 1,964 feet, and the Fraser River at Prince George on the date mentioned was 1855 feet.

Another noteworthy valley contains Tabor Lake, elevation 2,270 feet, and Tsadestsa Creek which trends north-easterly between Tabor Lake and the Willow River Valley, near the north-western extremity of the range dividing the Fraser and Willow River Valleys. The elevation of the Willow River at the junction of this valley is 2,105 feet, the junction being about 6 miles south of the western end of Eaglet Lake. The topography suggests that this valley may represent the up-stream course of a former large drainage-system (for example the northerly Fraser River drainage) through the Eaglet Lake - Aleza Lake - Hansard Lake Valley to the Herrick-McGregor River.

The break in the continuity of the Rocky Mountain Trench extends to the junction of the Pack and Parsnip Rivers. There the Trench is of normal size and position in relation to the Rocky Mountains and continues north-westerly without further interruption. South-east of the junction the Trench appears to split into two smaller branches. The easterly branch occupied by the Parsnip River trends in a south-easterly direction, but far to the east of the normal position of the Rocky Mountain Trench. The westerly branch occupied by the Pack and Crooked Rivers extends in a more southerly direction to the west of the normal position of the Rocky Mountain Trench, getting shallower in this direction and finally merging in the Nechako Plateau at Summit Lake. The triangular-shaped terrain between these trenches becomes progressively higher to the south-east reaching a maximum at the Arctic-Pacific Divide, which trends in a north-easterly direction from Summit Lake directly across the normal position of the Rocky Mountain Trench. One of the highest points in the Arctic-Pacific Divide, Averil Mountain, elevation 4,275 feet, lies almost directly

north-west of the end of the Rocky Mountain Trench near the Grand Canyon, where the normal proportions of the Trench are restored and continue south-easterly without further interruption.

It is apparent (Fig. 3) that the bend of the Fraser River after it emerges from the Rocky Mountain Trench near the Grand Canyon, is influenced by the disposition of local mountain structures, although the valley containing Hansard, Aleza and Eaglet Lakes appears a more natural alternative than the course followed by the river.

Upon emerging from the Rocky Mountain Trench, the Fraser River enters the Grand Canyon incised in a low range of hills, and then unconfined by any high walls meanders for a few miles at the extreme eastern edge of the Nechako Plateau. Below the junction of the McGregor River, the Fraser River makes the great bend at its most northerly point (Fig. 3), entering a valley incised between Averil Mountain, elevation 4,275 feet, on the north side of the river, and an unnamed mountain, elevation 3,117 feet on the south side of the river. Here the direction of flow changes from north-westerly to south-westerly. In this region, the northern rim of the valley rises sharply from the river to form the flanks of Averil Mountain, but the rise of the valley-rim on the south side is less steep. Although this part of the valley is steep-sided locally and rock-outcrops are numerous on both valley-rims, there is no suggestion of a canyon, and the term "Giscome Canyon" applied to the lower end of this part of the valley and so marked on some maps is a misnomer. Below Tay Creek, the river again enters the Nechako Plateau proper, and although the depth of incision increases down-stream, there is marked topographic contrast between those parts of the valley below and above "Giscome Canyon." Below it the valley considered as a whole is one of subdued relief with gently-sloping rims. This general aspect is not obscured by the high banks of glacial materials which flank the river on both sides at numerous points in this region. The number and size of these increase towards Prince George, where the deposition of glacial drift evidently derived both from the north-west and north-east is particularly heavy. Giscome Rapids, almost 7 miles in length, commence about 1 mile below Giscome Portage. These rapids appear to be due to the great accumulation of large boulders washed out of the glacial debris by the river in cutting down through this material.

Below the junction of the Nechako River at Prince George the Fraser River flows almost due south to Whites Landing.

Eighteen miles below Prince George, the Fraser River enters the Fort George Canyon, a rock-canyon 2 miles in length incised to a maximum depth of about 90 feet. It is apparent that the canyon lies immediately west of a former channel of the river, the down-stream end of which is cut by the river at the lower end of

the canyon. Here the deviation of the river from its former channel has been very slight.

Emerging from this canyon, the river continues its southerly flow. Between the south end of Woodpecker Island and a point just below the mouth of Canyon Creek, the Fraser River Valley is almost gorge-like for 1 1/2 miles. Both valley-rims steepen and the east rock-rim rises abruptly to a height of some hundreds of feet above the river. A short distance below Canyon Creek, the Fraser River Valley again assumes its character of mature relief. These features suggest that the short piece of valley mentioned may be younger than that part of the valley above and below it, and in conjunction with an embayment on the east side of the Fraser River at the south end of Woodpecker Island, suggest that a segment of an older valley lies buried to the east of the Fraser River Valley in this region. At Whites Landing, the river makes an abrupt bend, turning sharply to the west to flow south-westerly past the junction of the West Road River, and finally south-easterly to the point of entrance to the Cottonwood Canyon and below the latter to the mouth of the Cottonwood River.

There is sharp topographic contrast between two parts of this bend. Between Whites Landing and the mouth of the West Road River the river-valley is one of mature relief, whereas down-stream from the mouth of the West Road River, the valley may best be described as a mature rock-gorge hundreds of feet in depth. It is apparent that these two parts of the bend were incised at different times, and that the former is older than the latter, which was more rapidly incised.

Another large valley now occupied by the northerly-flowing part of Canyon Creek and its tributary Meadow Creek, lies considerably to the east of the Fraser River in this region. The east rim of this valley is formed by the western slopes of the range of mountains between the Fraser and Willow Rivers. Rock is cut by all the larger creeks (Government, Hixon and Terry, and the westerly-flowing part of Canyon Creek) draining the western slopes of this range. To the south this range merges in the plateau, but the deeply-incised rock-canyons on Ahbau Creek and the Cottonwood River suggest the southerly continuation of the eastern rock-rim. No rock-outcrops occur on the western rim of this valley contiguous to the northerly-flowing part of Canyon Creek and Meadow Creek. Still farther to the west, however, immediately west of Whitelanding Creek, rocks outcrop in a north and south direction. Whitelanding Creek having its source in Lazaroff Lake, with many western tributaries which meander on the plateau, maintains an almost due northerly flow to its junction with the Fraser River, increasing its depth of incision in the plateau down-stream. About 1 1/2 miles above its mouth it enters a rock-canyon about half a mile in length, and 320 feet deep, rock-walls being exposed for a height

of 140 feet. From this point south rock-outcrops occur at intervals in an almost due south direction (Figs. 1 and 2). Among the most southerly rock-outcrops are the canyons on McHardie Creek and its branches, and the Cottonwood Canyon on the Fraser River. It has already been mentioned that the Fraser River occupies a mature gorge some hundreds of feet in depth between the mouth of the West Road River and the Cottonwood Canyon. These facts suggest that the valley occupied by the northerly-flowing part of Canyon Creek and Meadow Creek is the unfilled part of a still larger valley trending in a southerly direction from near Whites Landing and bounded by the rock-rims mentioned and joining the Fraser River Valley near the mouth of the Cottonwood River. It is further strongly suggested that the Fraser River re-enters its former valley, cutting through the western rim at the extreme end of the Cottonwood Canyon about 1 mile above the mouth of the Cottonwood River. The eastern rim of the ancient valley in this region is the Cottonwood River Canyon at the highway-crossing.

The topography of the Fraser River below the Cottonwood River is described on pages 6 to 11 of British Columbia Department of Mines Bulletin No. 3, 1940. The rampart-like rock-exposures, chiefly of the Upper Volcanics, which cap the valley-rims of both the Fraser River and its tributaries at so many points between Quesnel and Soda Creek, forming an outstanding topographic feature in this region, were nowhere observed north of Quesnel in the region examined. If there were flows of the Upper Volcanics they have since been eroded over a large area.

McGregor River

The southwesterly-flowing parts of the McGregor River and Herrick Creek are virtually one and the same stream, which forms the navigable waterway occupying a large southwesterly-trending valley, which is about 12 miles in width at its junction with the Fraser River Valley. The northern wall of the Rocky Mountain Trench is terminated in this region by the gap caused by this valley-junction. The water-system indicated is for the sake of brevity termed the "Herrick-McGregor River" in this report, and its containing valley the "Herrick-McGregor Valley." This waterway was ascended by motor-boat as far as the junction of Fontoniko and Herrick Creeks, an estimated distance of 55 miles. On the northwesterly-flowing part of the McGregor River a boat cannot be used owing to numerous canyons, whereas Herrick Creek is navigable for a considerable distance above the junction of Fontoniko Creek. Navigation above the junction of James Creek is dangerous and should not be attempted without a local pilot. From a boat on the Herrick-McGregor River it is very difficult to detect the junction of the northwesterly-flowing part of the McGregor River owing to the great width of the valley, and to the number of parallel streams into which the waters divide. It is easy to pass

from the McGregor River to Herrick Creek without perceiving any difference in the volume of water. Although the northwesterly-flowing part of the McGregor River is not navigable, its volume may be greater than Herrick Creek, but there can be no question that the largest and oldest valley in this region is the Herrick-McGregor Valley.

Near its junction with the Fraser River, the flow of water in the McGregor River is sluggish, the river meanders in the wide valley with many ox-bow bends, and repeatedly splits into a number of channels. Peat bogs occur at several points in this part of the valley. The velocity of the water gradually increases up-stream. From a width of close to 12 miles at its mouth, the Herrick-McGregor Valley decreases in size upstream to between 3 and 3 1/2 miles near the junction of the northwesterly-flowing part of the McGregor River. Its width further decreases somewhat to its end at the mouth of Fontoniko Creek. The great size, depth of incision, and mature aspect are noteworthy features of this valley. There are no high glacial banks within the valley and few rock-outcrops close to the river except in a rock-canyon about 3 1/2 miles long and from 35 feet to 75 feet deep in which the river flows between points about 20 1/2 and 24 miles above its mouth. A gap in the canyon about half a mile in length at about three-fifths of a mile above the lower end, divides the canyon into two sections: a down-stream section three-fifths of a mile long, and an up-stream section somewhat under 2 1/2 miles long.

The mountain-structure to the east of this valley is noteworthy. North of the Fraser River and between it and the central ranges of the Rocky Mountains are three separate parallel, northwesterly-trending ranges, namely the Bearpaw, McGregor and Dazaiko ranges, all of which terminate north-westerly at the Herrick-McGregor Valley. The Bearpaw range forms the northern wall of the Rocky Mountain Trench, and the valley between it and the McGregor Mountains contains the Torpy River. The upper reaches of the McGregor River are confined between the McGregor and Dazaiko ranges, while the upper reaches of Herrick Creek flow between the Dazaiko range and the western slopes of the central ranges of the Rocky Mountains. A noteworthy example of trellis-type structurally controlled drainage is exhibited by the rivers in this region. These local ranges all rise to elevations of not less than 3,500 feet above the river-systems at their bases. On the northern side of the Herrick-McGregor River Valley and the Fraser River Valley below the junction, is an irregular mountain assemblage, along the high points of which the Arctic-Pacific Divide trends north-easterly. The elevation of points on this divide increases from little more than 2,300 feet south of Summit Lake to 4,275 feet at Averil Mountain, and to over 6,500 feet (Fig. 3) near the Rocky Mountain Divide.

Noteworthy is the fact that the direction of flow of large tributaries of the Herrick-McGregor River on the north-western side, is accordant with a north-easterly flowing parent stream, which suggests a possible reversal of flow in the Herrick-McGregor River.

There is a dense growth of vegetation and underbrush in the bottom and lower valley-slopes of the north-westerly trending part of the Fraser River Valley and of the Herrick-McGregor River Valley, and for the most part mountain-slopes are heavily timbered up to an elevation of about 5,000 feet. The underbrush is markedly less dense, and timber-growth less heavy in that part of the Fraser River Valley which is incised in the Interior Plateaux.

Nechako River

Only the lower 13 miles of the Nechako River Valley was examined in detail. A brief examination was made of a few points farther up-stream in view of their bearing upon the Fraser River Tertiary drainage-history.

After flowing north-easterly with many meanders in a wide valley of mature relief, the Nechako River makes a bend, 8 miles up-stream from Prince George, the direction of flow changing to south-easterly and easterly. Immediately down-stream from this bend to its junction with the Fraser River at Prince George, terraced flats of great size flank both banks of the Nechako River, save directly north of Prince George. This has formed a delta-like area, extending mainly south of the river at the mouth of the Nechako River, on which the city of Prince George is situated. The length of this delta is about 6 1/2 miles and the width at the mouth is about 3 3/4 miles (Fig. 4). On the south side of the river this area is bounded at its western extremity by a rock-rim about 675 feet in maximum height, which rises sharply to the Nechako Plateau. On the north side of the Nechako River the valley-rim rises even more sharply at the northern edge of the delta-like area, but consists wholly of banks of clay, sand, silt and gravel, about 355 feet in height. The deposition of glacial debris is heavy for many miles north of the river in this region and rock is obscured. So far as is known, the only rock-outcrop is Pilot Mountain, elevation 3,275 feet, an erosion remnant on which there is a "Look-out" station, erected by the Forest Branch of the Department of Lands. It is about 5 miles due north of the river (Fig. 2). Due to the deep incision of the Fraser and Nechako Rivers in this region, which reaches an average depth of about 370 feet near the rivers, the delta-like area is hemmed in on all sides save by the gaps formed by river-valleys. Near the mouth of this area are two prominent flat-topped, oval-shaped knolls. The distance between them is somewhat over a mile, and the elevation of the top of the more northerly is 190 feet above

the Fraser River; the more southerly is about 20 feet higher. It is clear that these are erosion remnants, because a slough still exists at the northern base of each knoll. The one at the base of the southern knoll, known as the "Hudson Bay Slough," emerges in the Fraser at South Fort George. These sloughs undoubtedly indicate paths followed by the post-glacial waters of the Nechako River in cutting down through the great mass of glacial debris which must formerly have occupied the Nechako and Fraser River Valleys in this region. A progressive shift of the post-glacial Nechako River channels to the north indicates an attempt by this river to again occupy a pre-glacial channel lying to the north from which it was diverted. Although the slopes of the Nechako River Valley are well-timbered, the underbrush is less dense than in the north-westerly trending part of the Fraser River Valley and Herrick-McGregor River Valley.

GLACIAL GEOLOGY

Although Pleistocene drainage-history is not pertinent to the subject of this report, it was found necessary to devote some time to the study of Pleistocene features to differentiate between certain Pleistocene and Tertiary deposits of lacustrine type. The attention of the writer was directed to one fact by C. C. Kelley of the Department of Agriculture which, it is believed, is not generally known. Within a large area centering about Prince George, following or during the final retreat of ice, but before restoration of drainage, a large lake, or lakes was formed adjacent to the Fraser River and its tributary drainage-system. In this lake or lake deposits of varved clay were laid down on the top of the pre-existent glacial deposits. Many exposures proving this were found at points within a radius of 20 miles of Prince George and farther south in the Fraser River Valley. Although details of sections are given subsequently in this report, it might be mentioned that exposures invariably show the varved clay above the glacial drift, but not always directly above. Sometimes a few feet of river silt overlies the glacial debris, indicating restoration of sluggish drainage for a brief period, followed by cessation of flow and formation of a lake. In some instances the varved clay is directly overlain by soil, in others by a few feet of post-glacial gravel. The varved clay deposits are apt to escape detection unless examined closely, because from a distance they closely simulate deposits of river-silt. The exact area occupied by the glacial lake or lakes is being investigated in detail in the course of the soil survey of a large area centering about Prince George now being undertaken by the Dominion and British Columbia Departments of Agriculture, under the direction of C. C. Kelley of the latter Department. Apart from its particular purpose, this survey will be of direct geologic interest and utility, not only because of the information supplied concerning deposits of varved clay, but inasmuch as the survey involves a traverse of boundaries of all pre-emption lots, few if any rock-outcrops will escape detection. The exact location of these in a large drift-obscured area will be of much value.

Within that part of the Fraser River Valley examined to date, it is evident that deposition of glacial drift within the valley is responsible only for local and quite minor deviations of the present river from its Tertiary channels. As mentioned under "Topography" the two bends of this river originated before the Pleistocene epoch. On the other hand, because the deposition of glacial drift within a large area centering in Prince George was heavier than at other points, there is much to suggest that the course of the Nechako River near Prince George has been influenced by the deposition of glacial debris. The courses of two successive post-glacial channels of the Nechako River are plainly indicated by sloughs on the delta-like area near the mouth of this river. These

indicate the uncommon feature of a progressive shift of the post-glacial waters to the north, in opposition to the southerly flow of its master-stream the Fraser River. It is reasonable to suppose that the Nechako River was caused to bend to the south near Prince George by the reversal of flow in the Fraser River from northerly to southerly in late Cretaceous time. The deposition of lacustrine sediments in Tertiary time near the mouth of the Nechako River in its Tertiary channel, followed subsequently by a great mass of glacial debris, may be the reason for the shift of post-glacial waters to the north. Before reversal of drainage in the Fraser River, the Nechako River may have occupied a channel considerably north of its present course.

The nature and distribution of the glacial boulders leaves no doubt that the movement of the ice-sheet across the Interior Plateaux west of the Fraser River was south-easterly. It is equally clear that within a large area centering in Prince George, drift was also derived from the south-westerly movement of an ice-sheet from the Rocky Mountains. This is proved by the development of many roches mountonnées on the granite stock to the north of Eaglet Lake, the south-westerly direction of which plainly indicate the south-westerly movement of the ice-sheet.

There is thus a mixture of drift from several sources near Prince George. The boulders of batholithic rocks were doubtless derived mainly from the north-west, as were also the boulders of post-Palaeozoic rocks, whereas boulders of the Palaeozoic rocks may have been derived from either the north-west or north-east. Boulders of gneissic rocks were probably derived from the north-east. Some of the glacial banks on the north side of the Nechako River are 465 feet in height. The numerous deposits of stratified sand, silt and clay which flank the rivers indicate that the glacial debris was cut through slowly.

In striking contrast to the heavy deposition of glacial drift in the Fraser River Valley near Prince George is the almost entire absence of glacial drift in the adjacent Eaglet Lake - Aleza Lake - Hansard Lake Valley. This latter valley is largely unfilled, and even assuming that some drift was shifted by post-glacial waters it is improbable that much has been removed by this agency. To support this theory there is an absence of gravel terraces flanking the rims of the valley. The probable reason seems to be that the region in which this valley is situated received drift mainly borne by the south-westerly moving ice-sheet.

The Fort George Canyon is a post-glacial feature, and it is clear that a former channel of the Fraser River lies buried immediately east of the canyon. The down-stream end of this channel is cut by the present river at the lower end of the canyon and an excellent section exposed. This channel is possibly of late

Tertiary age, although it may be interglacial. The matter is discussed later in this report under "Tertiary Fraser River Sediments."

The great depth of the Cottonwood Canyon suggests that incision may have been commenced in Pleistocene time. In the case of this canyon also, a former channel of the Fraser River lies buried to the east, namely the Tertiary Mine - Canyon Mine channel, described in British Columbia Department of Mines Bulletin No. 3, 1940, but this is of undoubted Tertiary age.

BED-ROCK GEOLOGY

Bed-rock geology was studied primarily in connection with its bearing on Tertiary drainage-history as indicated by geographic distribution, topographic position and form. In the case of fossiliferous formations, age was determined from palaeontological evidence, following examination of all specimens by the Palaeontological Section, Department of Mines and Resources, Ottawa, but no attempt was made to correlate widely-separated rock-outcrops. In descriptions of the latter, the context renders clear that any suggested correlation with known formations, based upon such factors as degree of metamorphism and lithology can be regarded as tentative only.

Points of interest are:-

(a) The number of intrusive bodies in the rocks cut by the Fraser River between the Cottonwood Canyon and a point west of Woodpecker.

(b) Batholithic stocks of considerable size occur at the following points:

(1) Quartz-diorite on the west side of the Fraser River near Whittier Creek.

(2) Diorite on the west side of the Fraser River opposite McHardie Creek.

(3) Diorite east of the Fraser River west of a point about 4 miles south of Whites Landing.

(4) Granite, alaskite and diorite on the southern rim of the Nechako River Valley near Prince George.

(5) Granite to the north of Eaglet Lake.

(c) A tongue of diorite intrudes limestone at the summit of the northern wall of the Rocky Mountain Trench, to the northeast of Sinclair Mills.

In the description which follows, to facilitate reference, all exposures of the various Tertiary channels of the Fraser River are grouped together and described under "Tertiary Fraser River Sediments." Exposures of sediments of the Tertiary West Road (Blackwater) River are also separately described under, "Tertiary West Road (Blackwater) River Sediments."

Fraser River Valley

The Grand Canyon, about 9 miles up-stream from Sinclair Mills, is incised in an isolated rock-ridge of intra-valley type situated immediately below the point at which the southern wall of the Rocky Mountain Trench ends (Geol. Surv. Canada, Summ. Rept. 1909, pp. 123-130). At the time of examination it was not possible to navigate the canyon, owing to the constant passage of logs, and for this reason only the lower end of the canyon was examined. The rocks exposed there consist of an assemblage of interstratified beds of quartzite, sandy limestone, shale and slaty argillite. Fossils were found both in the shale and in the underlying limetone, at the locality indicated (Fig. 3). Specimens were submitted to the Palaeontological Section, Department of Mines and Resources, and Dr. F. H. McLearn reported thereon as follows: Specimen from carbonaceous shale - "Contains badly distorted specimens of at least two species of trilobites, Olenellus, sp, and Bonnia, sp. The preservation is too poor for identification of species and even too poor for exact determination of the genus. The age is Lower Cambrian."

Specimens from limestone underlying shale: "Contains the trilobite Bonnia, sp. The age is Cambrian, probably Lower Cambrian."

This assemblage of rocks strikes mostly from north 37 to 72 degrees west and dips from 32 degrees to 65 degrees south-westward. At one point a north-eastward dip was observed due to folding, and at another point a strike of north 73 degrees east, with southward dip. There is some copper mineralization in these rocks.

One mile below the Grand Canyon, is a small outcrop of limestone on the southern bank of the river, but no other rock-outcrops occur close to the river between this point and one about 8 miles below the mouth of the McGregor River.

The northern end of the Bearpaw Mountains was ascended for the purpose of determining the bed-rock geology. This end of the range lies to the north-east of Sinclair Mills, and an indifferent foot-trail about 7 miles in length, somewhat hard to follow, leaves Sinclair Mills and switchbacks up the densely-timbered mountain-slope. A triangulation-station of the Department of Lands, elevation 5,557 feet, 3,500 feet above the Fraser River, is at the summit of the north-western end of the Bearpaw Mountains. The bed-rock at the summit of the range consists of wavy lime schist intruded by a tongue of fine-grained diorite 35 feet in width with a marginal phase of pyroxene porphyry. In the vicinity of the latter the limestone shows a zone of silicification several feet in width containing diopside and basic feldspar. The limestone strikes from north 2 to 12 degrees west

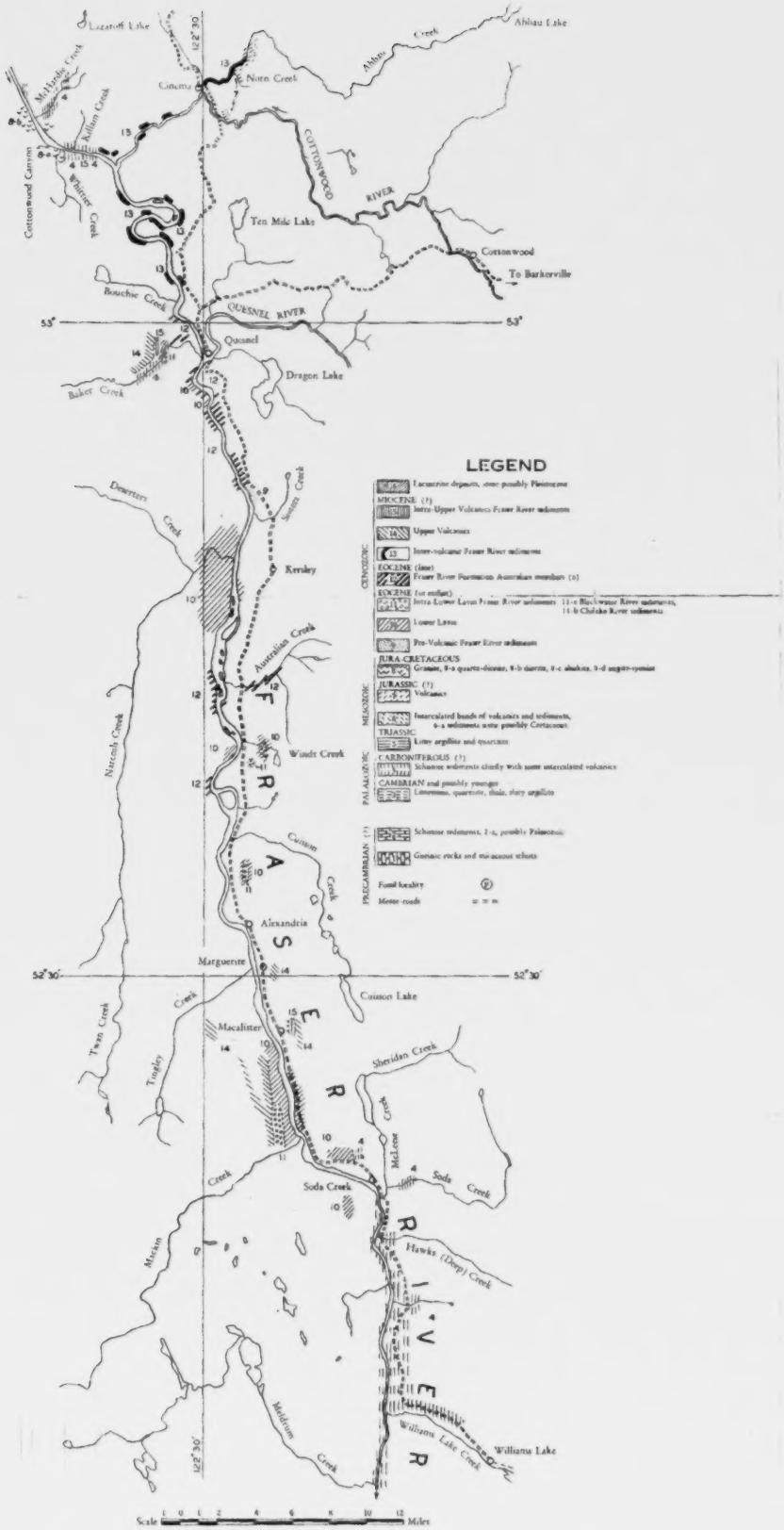


Fig. 1. Plan of Fraser River extending from Williams Lake to Quesnel.

and dips westward from 75 to 80 degrees. The size of the tongue was not determined but it may be considerable in view of the degree of alteration of the limestone and because of the presence of pebbles and boulders of batholithic rock in the creek-beds on the mountain slopes.

About three-quarters of a mile south of the Fraser River, 2 1/2 miles north-west of Hansard station on the south side of the motor-road (Fig. 3), is an outcrop of greyish-white limestone about 150 feet long and 65 feet high. The limestone is massive and strike and dip are not clearly defined. Apparently the strike is north 29 degrees west and the dip 75 degrees south-westward. About 1 mile north-west of this exposure, also on the south side of the motor-road is another small outcrop of limestone. These outcrops appear to form the southern rim of the valley now occupied by Eaglet, Aleza and Hansard Lakes, near the mergence of this valley with the Fraser River Valley. The limestone is possibly the same age as that exposed in the Grand Canyon. Outcrops of thinly-bedded limestone, strike north 42 degrees west, dip 27 degrees south-westward, occur on the north and south banks of the Fraser River about 7 1/2 miles down-stream from the mouth of the McGregor River, and also approximately 1 mile down-stream from this point. A small outcrop of thinly-bedded schistose quartzite, strike north 67 degrees west and dip 80 degrees north-eastward, can be seen on the southern bank of the Fraser about 1 mile lower down.

About 5 miles up-stream from Averil Creek, a small creek, locally named Fish Creek, flows almost due south into the north side of the Fraser River. A large, grey-coloured, cliff-like rock-outcrop, the most prominent rock-exposure in the neighbourhood, visible from the river, occurs to the east of the headwaters of this creek approximately 2 miles northerly from the Fraser River. Examination proved this to be thinly-bedded, grey-white limestone, strike north 39 degrees west and dip 60 degrees north-east. The top of this cliff-like exposure is 1,030 feet above the river. Coarse-grained quartzite, strike north 32 degrees west and dip 45 degrees south-westward, outcrops to the north-east of this exposure, 525 feet above the river.

Rock-outcrops are numerous at and near the most northerly point of the Fraser River from Averil Creek down-stream for about 4 miles, where the Fraser River Valley is steep-sided, and in the lower part of Averil Creek Canyon. All these strike mostly from north 42 to 72 degrees west and are pronouncedly micaceous and schistose. They comprise silicified quartz-muscovite schists, quartz-biotite schists and quartz-sericite schists and are radically different lithologically from the rocks hitherto described on this and the Herrick-McGregor River. About 1 mile above its mouth Averil Creek emerges from a deep rock-gorge some miles in

length, of which the lower 2 miles were examined. The walls of the gorge are some hundreds of feet in height and afford an excellent cross-section of the micaceous rocks. At a point 3 miles from the Fraser River, the micaceous rocks are apparently overlain by limestone on the east side of the canyon. These micaceous rocks may be of Precambrian age. The scheelite-bearing quartz veins in this region are described in the Annual Report, Minister of Mines, British Columbia, 1935, pp. C30 to C32. The micaceous rocks do not outcrop near the river below a point 3 miles down-stream from Averil Creek. Between Giscome Canyon and Prince George, rock-outcrops are few. Exposures of sediments of the inter-volcanic Fraser River occur at points 1 1/2 and 5 miles down-stream from Giscome Portage, and are described subsequently under "Tertiary Fraser River Sediments." A small outcrop of argillite, strike north 37 degrees west, dip 20 degrees north-eastward, occurs on the eastern side of the river approximately 1 mile down-stream from the last point.

Schistose greenstone is exposed three-quarters of a mile down-stream from the mouth of the Willow River on both sides of the river. At this point on the east side of the river greenstone with some intercalated tuff beds is exposed over a length of 1,050 feet and height of 120 feet. These rocks strike north 8 to 18 degrees west and dip from 53 to 70 degrees westward.

Exposures of interstratified conglomerate and sandstone on the eastern bank of the river somewhat over 3 miles to the north of Shelley, are believed to represent the Eocene or earlier pre-volcanic channel of the Fraser River and are described later.

Between the last-mentioned exposure and Prince George, no rock-outcrops occur near the river, but to the east the Nechako Plateau may be but thinly covered with glacial debris as low rock-outcrops are not infrequent. Almost due east of Prince George, immediately east of Tabor Lake, is the mountain known locally as "Six-Mile Mountain" elevation 4,125 feet, at the northwestern end of the range between the Fraser and Willow Rivers. The rocks exposed on Six-Mile Mountain, and on the Nechako Plateau to the east consist of schistose sediments and intercalated volcanic flow-rocks locally intruded by tongues of batholithic rock. The average strike is north 10 degrees west and the dip 20 degrees to the west. These rocks contain slightly cupriferous and auriferous quartz veins from which doubtless the placer-gold found on Skaret Creek in this region was derived (see Annual Reports of the Minister of Mines, British Columbia, for the years 1932, 1933 and 1934).

South of Prince George there are no outcrops on the river banks for a distance of 18 miles, except clays and other members of the lacustrine deposits above and below Tabor Creek, described under "Tertiary Lacustrine Deposits."

The river then enters the Fort George Canyon, a steep rock-walled canyon, the length of which is about 2 miles and maximum

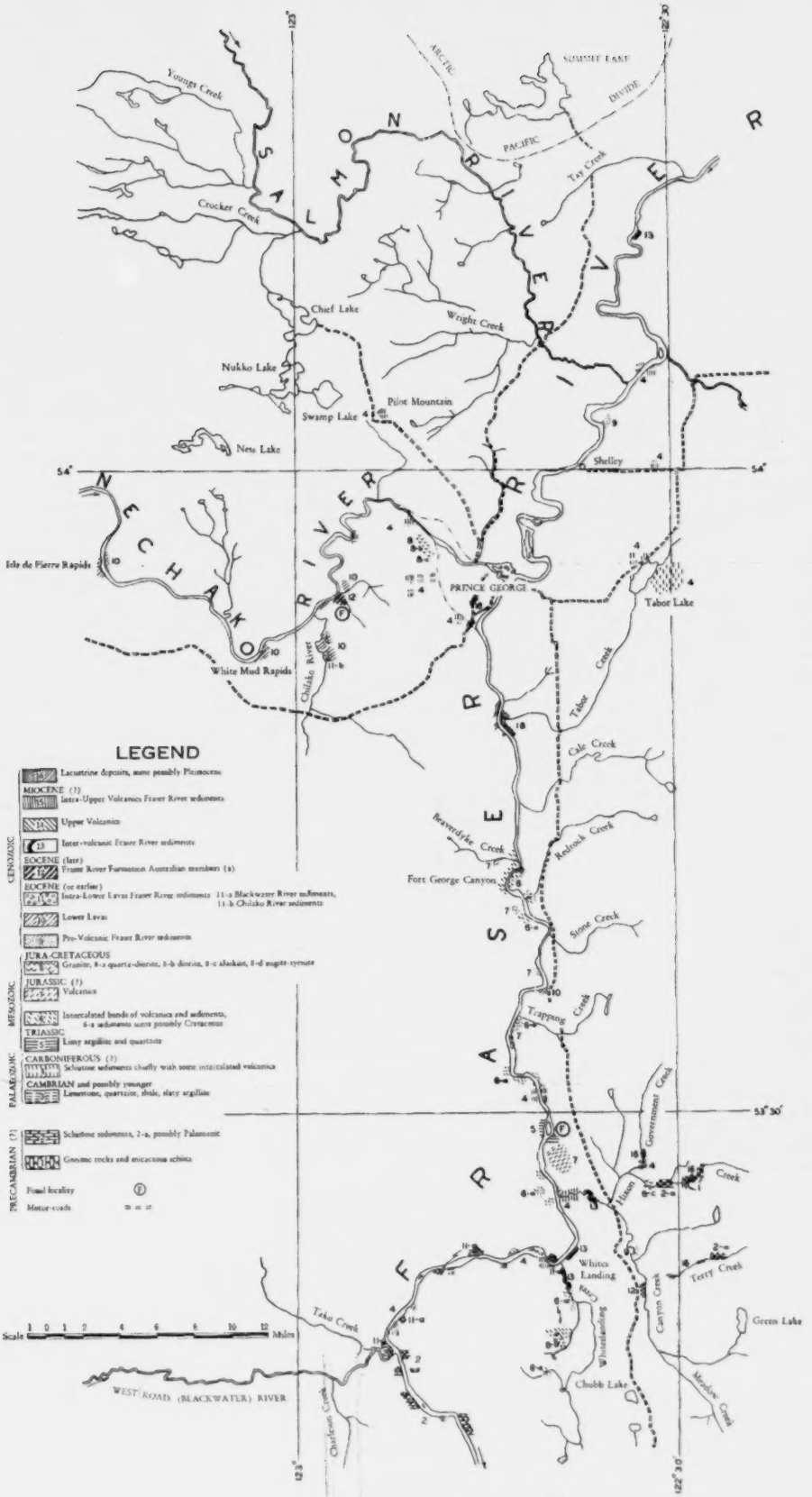


Fig. 2. Plan of Fraser River extending from Quesnel to Summit Lake.

height of walls 90 feet. As will be seen (Fig. 2), rock-outcrops are frequent in a length of 4 miles of the river in this region. These rocks consist of an assemblage of wide alternating bands of andesitic and basaltic volcanic flow-rocks and limy argillites probably of Mesozoic age, which strike from north 12 to 42 degrees west and dip from 35 degrees north-eastward to nearly vertical. A prominent member of this assemblage is a porphyry with phenocrysts of hornblende which is locally much fractured and weathered to a deep-red colour owing to the development of hematite in the numerous fractures. An outcrop of this red-coloured rock occurs on the east side of the Fraser River just above the junction of Redrock Creek. Redrock Creek enters the Fraser River in a gorge 85 feet in height incised in well-lithified conglomerate of noteworthy coarseness. All pebbles and boulders therein are waterworn and some are between 3 and 4 feet in diameter. The matrix appears to be mainly derived from andesitic and basaltic rocks. Overlying the conglomerate are interstratified argillite and coarse-grained sandstone. These rocks strike north 50 degrees west and dip 35 degrees north-eastward.

On the west side of the river, opposite a point 2 1/2 miles down-stream from Stone Creek, there is a small outcrop of porphyritic flow-rock with phenocrysts of hornblende.

On the east bank of the river 1 1/2 miles above the mouth of Trapping Creek, coarsely-crystalline basalt resembling basalt of the Lower Lavas of Eocene or earlier age, outcrops over a height of 35 feet and length of 300 feet. Small diorite sills about 6 inches in width intrude the separation-planes between the lava flows.

Just below the mouth of Trapping Creek, is a small outcrop of thinly-bedded limestone strike north 14 degrees west, dip 45 degrees westward. A quarter of a mile farther down-stream on the same side of the river, are small outcrops of andesite and basalt.

Between a point 3 miles down-stream from Trapping Creak, and the south end of Woodpecker Island, the river runs over bed-rock in many places, and rock-outcrops on both banks are frequent. On the west side of the river opposite the first point, and on the east side of the river three-quarters of a mile down-stream from it, argillites strike from north 40 to 54 degrees west and dip from 50 to 80 degrees south-westward. On the east side of the river they are apparently intruded by a tongue of porphyritic rock with phenocrysts of biotite.

Much metamorphosed and contorted argillite, which may be of Palaeozoic age, is exposed on the east side of the river for a distance of somewhat over a mile further down-stream and on the opposite bank of the river. This rock is intruded by large chloritized acidic tongues. On both sides of the river at the

southern end of Woodpecker Island are large outcrops of calcareous argillite and quartzite, strike north 67 west and dip 53 degrees south-westward. On the east side of the river at this point fossils were found in these rocks (Fig. 3). A specimen was sent to the Palaeontological Section of the Department of Mines and Resources, and Dr. F. H. McLearn reported as follows: "Contains fragments of a pelecypod, Halobia or Daonella. The age is Triassic."

On the east side of the river the Triassic rocks form the northern end of a large rock-outcrop which rises to a height of several hundred feet above the river, and extends southerly for 1 3/4 miles, forming the eastern rim of the valley in this region. Volcanic rocks probably of Mesozoic age with a few intercalated beds of argillite, overlie the Triassic rocks near the northern end of the large rock-outcrop mentioned, but vegetation obscures the contact. These volcanic rocks are exposed almost continuously on the Pacific Great Eastern Railway grade, 380 feet above the river, for 1 1/2 miles to the south of the Triassic rocks.

On the east of the river 1 1/2 miles down-stream from the south end of Woodpecker Island, and on the west bank of the river opposite this point, are low outcrops of argillite of indicated Mesozoic age intruded by diorite. The argillite strikes from north 50 to 87 degrees west and dips from 50 to 75 degrees south-westward.

Argillite of apparent Mesozoic age intruded by dioritic tongues, is exposed half a mile above the mouth of Canyon Creek on the east side of the Fraser River and on the west side of the river opposite this point in a creek-bed. The argillite strikes north 87 degrees west and dips 75 degrees southward.

Canyon Creek is contained in a steep rock-walled canyon for a distance of 1 1/2 miles above its junction with the Fraser River, and the mouth of the canyon forms a prominent rock bluff on the east bank of the Fraser River at this point. The rock in the canyon is wholly slaty artillite, intruded by numerous small dioritic tongues. The argillite strikes north 77 degrees west and dips 55 degrees southward. The age may be Palaeozoic.

Outcrops of sediments of the inter-volcanic Fraser River occur on both sides of the river near Whites Landing and are subsequently described under "Tertiary Fraser River Sediments."

Rock exposures near the Fraser River are mostly a few feet in height, except near its confluence with the West Road River. In this part of the Fraser River Valley are exposures of sediments of the Tertiary West Road River which are described later.

On the southern bank of the river half a mile down-stream from the mouth of Whiteslanding Creek, slate outcrops at the river's edge for almost half a mile, strike north 51 degrees east and dip 36 degrees south-eastward. The slate is intruded by tongues of diorite. On the northern bank of the river, approximately 3 miles down-stream from Whiteslanding Creek, beds of slate and interstratified limy quartzite, much contorted, are intruded by acidic tongues. Small quartz gash-veins are developed in the sediments and intrusive bodies. The slate may be Palaeozoic.

Three-quarters of a mile down-stream from the exposure of slate on the southern side of the river is an outcrop of dark-blue limestone, strike north 52 degrees west and dip 75 degrees north-eastward.

Two miles down-stream from the last described exposure on the northern bank of the river, argillite intercalated with schistose volcanic rocks, strike north 34 degrees west with nearly vertical dip, is intruded by a diorite tongue. This exposure underlies an exposure of Tertiary sediments of the West Road River.

On the eastern bank of the river 2 1/2 miles above the mouth of the West Road River schistose grey-black quartzite is exposed, strike due east and dip 40 degrees south. Similar rocks are exposed on this side of the river 1 mile down-stream. Half a mile farther down-stream on the same side of the river an outcrop of schistose greenstone strikes north 48 degrees east and dips 35 degrees south-eastward. In the time available it was possible to examine only a few of the rock-outcrops situated at high elevations between the West Road River, and the Cottonwood Canyon. Schistose sediments, chiefly quartzite and argillite, are exposed from half a mile above the mouth of the West Road River down-stream for 6 miles and resemble those of the Cariboo series of Precambrian age. Their strike varies from north 68 degrees east with a south-eastward dip to north 72 degrees west with a south-westward dip. They are intruded at one point by dykes resembling the Proserpine dykes with a development of quartz gash-veins in the vicinity.

From 1 1/2 miles above McHardie Creek down-stream to the end of the rock exposure 1 mile above Cottonwood River, the schistose rocks exposed closely resemble those of the Cache Creek series.

On the east bank of the river 1 1/2 miles above McHardie Creek schistose quartzite outcrops strike north 72 degrees west and dip 75 degrees south-westward. On the west side of the river opposite this point a large outcrop of diorite forms the west valley-rim. McHardie Creek flows in a deep gorge incised

in schistose sediments, which ends 1 mile above its mouth. A bluff of granitic rock occurs one mile below this creek, on the eastern bank of the Fraser River. At the head of the Cottonwood Canyon quartz-diorite outcrops at the mouth of Whittier Creek and on the bank of the river opposite this point intruding schistose sediments. The Cottonwood Canyon is about 1 mile in length; the depth at its head of about 375 feet decreases down-stream to where the river emerges from it at the Tertiary Mine. Rock is exposed on both sides of the river for upwards of a mile farther down-stream. The rocks exposed in the Cottonwood Canyon and on both sides of the river below the canyon are schistose; quartzite, limestone, and argillite. These rocks strike north-westerly and dip south-westward mostly at steep angles. Between the last described exposures and Soda Creek, with the exception of a small outcrop of argillite on the west side of the river 1 mile above Kenn Creek, no outcrops of pre-volcanic rocks (those older than the Lower Lavas of Eocene or earlier age) were found on either bank of the river. Baker Creek Canyon is incised in sediments which at one point are overlain by valley-fill occurrences of the Lower Lavas. Rampart-like exposures of the Upper Volcanics in Baker Creek and large outcrops of the Lower Lavas occurring on the west side of the river near Narcosli Creek and on both sides of the river between Macalister and Soda Creeks are described in British Columbia Department of Mines Bulletin No. 3, 1940.

Exposures of Australian members (a) of the Fraser River formation outcrop at various points from 5 miles north of Quesnel to the Alexandria Ferry, a distance of somewhat over 30 miles. Large exposures of these sediments occur near Quesnel (where the unconformable contact between these sediments and the Lower Lavas is exposed at low stages of water in the bend of the river three-quarters of a mile below Quesnel); at Rich Bar, 4 miles down-stream from Quesnel; 1 1/2 miles below Rich Bar on both sides of the river; on Australian Creek; on the west side of the river opposite Australian Creek and near Alexandria Ferry on both sides of the river. Between Soda Creek and Chimney Creek the river is incised wholly in sediments resembling the Cache Creek series.

Region east of the Fraser River between Whites Landing and the mouth of the Cottonwood River

A reconnaissance was made of this region to delimit the rock-rims of an ancient valley, which is now largely filled save at its northern end. The existence of this valley is suggested by features enumerated under "Topography" and its occupancy by some of the Tertiary Fraser River channels proved by the occurrence of sediments described subsequently under "Tertiary Fraser River Sediments." The approximate position of this valley is indicated in Fig. 1, of British Columbia Department of Mines Bulletin No. 3, 1940.

The most southerly rock-exposure of the western rim is cut by the Fraser River about 1 mile above the Cottonwood River (Fig. 1), from which point rock is exposed continuously to the head of the Cottonwood Canyon on both sides of the river, save for the gap caused by the crossing of the Tertiary Mine - Canyon Mine channel. At this point, the Fraser River after having left its former valley at Whites Landing, and making a detour to the west around it, again re-enters it, cutting through the western rim.

Exposures to the north of the last-mentioned point are distributed in an almost due north and south line to the west of Whiteslanding Creek.

Thinly-bedded fissile argillaceous quartzite, resembling quartzite of the Cache Creek series, strike north 23 degrees east and dip 25 degrees south-eastward at elevation 2,665 feet, are cut by a small tributary of Whiteslanding Creek 3 1/2 miles north of Lazaroff Lake.

To the north of the last-described exposure the Fraser Plateau becomes hilly, and at several places to the west of a point approximately four miles south of Whites Landing outcrops of diorite occur, and at one point limestone apparently of Mesozoic age is intruded by diorite. These last outcrops occur at elevations of between 2,600 and 2,680 feet on a series of rocky ridges, distributed in a north and south direction.

An outcrop of argillite apparently of Mesozoic age intruded by diorite, occurs 340 feet above the bed of the creek about 1 1/2 miles northwesterly from the last point. In the bed of the creek, 1 3/4 miles above its mouth, argillite intruded by diorite is also exposed. A short distance below this point the creek enters a rock-canyon. The rock exposed in the canyon is chiefly carbonaceous argillite intruded by diorite tongues. A small outcrop of andesite occurs at the lower end of the canyon. The argillite strikes north 59 degrees west and dips 50 degrees northeastward. The rocks exposed in this canyon resemble those of Mesozoic age.

To the east of Canyon Creek the east rim of the ancient valley is more clearly defined topographically than the west rim, as it is formed by the western slopes of the mountain range dividing the valleys of the Fraser and Willow Rivers, which merges southerly in the plateau-like region near Ahbau Creek, and the Cottonwood River. The western slopes of the mountain-range are drained by Hixon Creek and its tributary Government Creek; by Terry Creek, and by the westerly-flowing part of Canyon Creek. Bed-rock is exposed at various points on these creeks, some hundreds of feet above the floor of the valley containing the northerly-flowing part of Canyon Creek.

Government Creek enters a deep rock-walled canyon somewhat over 1 mile above its junction with Hixon Creek. At the upper end of the canyon the rocks are argillite intruded by tongues of batholithic rock. The argillite may be of Palaezoic age. Up-stream the creek cuts a series of thinly bedded fissile schistose sediments. In places the strike is east with dip to the north of about 45 degrees; at other points the strike is north 47 degrees west, with dip of about 45 degrees north-eastward. An occasional dip to the south-westward was observed. Similar schistose sediments are exposed on Hixon and Terry Creeks, and at all these points resemble the schists of the Cariboo series, though they may be of Palaezoic age.

About 3 miles above its mouth, Hixon Creek cascades over falls 60 feet in height incised in augite-syenite. About 2 miles farther up the creek, fissile schistose sediments are exposed in the bed of the creek and on the valley rims at different points for a distance of about 1 mile. The sediments strike mainly north 40 degrees west, and dip north-eastward at steep angles. The character of the rocks changes about 6 miles above the mouth of the creek and from this point up-stream for about half a mile on both sides of the creek, silicified biotite schists are exposed at intervals. These also strike north-west and dip north-eastward. The contact between these rocks and the fissile schistose sediments is not exposed. The fissile schists somewhat resemble members of the Cariboo series.

About 5 miles above its mouth on its northern bank, Terry Creek cuts schistose argillite, strike north 18 degrees east, dip 65 degrees eastward. The creek was not examined above this point in 1940, and no previous detailed examination of the exposed bed-rock had been made. It is reported however that the bed-rock exposed at various points up-stream consists of metamorphosed schistose sediments with some intercalated volcanics intruded at various points by tongues of batholithic rock. At about 6 miles above its mouth the creek flows through a rock-gorge and at about 7 miles above its mouth is contained in a rock-canyon about 1000 feet in length, the walls of which are about 90 feet in height.

Canyon Creek and up-stream from a point 3 miles above its junction with Meadow Creek, is contained in a steep-sided canyon-like valley for a length of about 4 miles. The rocks exposed in this gorge are volcanic flow-rocks and argillite intruded at one point by a tongue of batholithic rock.

Australian members (a) of the Fraser River formation are exposed on the west bank of Canyon Creek, approximately 4 miles down-stream from its junction with Meadow Creek. At 36.8 miles north of Quesnel, the terminus of the Pacific Great Eastern

Railway, a branch motor-road leaves the highway and leads to the east side of Canyon Creek, crossing the railway-grade built beyond Quesnel on the west side of this creek about half a mile from the highway. The above exposure is reached by following the railway-grade southerly for half a mile from the road crossing. The exposure is on the bank of the creek about one hundred feet west of the point indicated on the railway-grade.

At this point, interstratified clay beds containing seams of lignite of a maximum thickness of 1 1/2 feet, and beds of fine gravel, overlain by coarse gravel containing pebbles up to 8 inches in diameter, have been gently folded into a syncline. The exposure which rises vertically from the water's edge on the west bank of the creek is 300 feet long and 45 feet high, and is unconformably overlain by a few feet of post-glacial gravel.

At the up-stream end of this exposure the following section is afforded. At the top of the bank; soil and post-glacial gravel 5 feet; lignitic clay, 2 feet; coarse gravel, 10 feet; lignitic clay 2 to 3 feet; coarse gravel, 12 feet; sandy clay beds with seams of lignite (one of which is 1 1/2 feet thick) 10 feet. The base of the sandy clay beds is at water-level. The sediments strike north 8 degrees east and dip 35 degrees westward.

The Cariboo Syndicate under the direction of D. D. Fraser of Quesnel, sank a shaft in 1929 immediately up-stream on a small bench on the same side of the creek about 5 feet above water-level. This is now full of water, but D. D. Fraser states that the shaft was sunk to a depth of 85 feet, disclosing the continuation of alternating beds of cemented gravel and silt dipping about 26 degrees westward. There was a noticeable amount of mica present in both silt and gravel. Pebbles in the gravel were largely of granitic rock. From the bottom of this shaft a hole was bored with a Keystone-drill which reached granitic bed-rock at a depth of 160 feet below the surface. This hole was continued for a distance of 15 feet in bed-rock. The drill-hole disclosed a continuation of the gravel and silt beds with much lignite.

Distant 840 feet south of this shaft on the west side of the Pacific Great Eastern Railway-grade, a thickness of 35 feet of poorly-sorted coarse sub-angular gravel-beds, strike northerly and dip 30 degrees westward, is overlain by 55 feet of well-sorted gravel, horizontally stratified. The imbrication of the latter indicates a northerly flow of the waters by which they were laid down, presumably those of Canyon Creek. The pebbles in the inclined gravel are largely derived from granitic rock. The total length of this exposure is 180 feet and height 90 feet. Vegetation conceals the uppermost few feet of the exposure. On the east side of the Pacific Great Eastern Railway-grade, distant

3,030 feet southerly from the shaft, cemented beds of coarse sub-angular gravel, with pebbles up to 10 inches in diameter, are exposed at intervals for a length of 200 feet and height of 25 feet. The beds strike north 53 degrees east and dip 30 degrees south-eastward, and are overlain by from 5 to 10 feet of post-glacial and glacial gravel.

The three last-described exposures plainly indicate that before the Australian members (a) of the Fraser River formation were folded, there was a strong flow of water over them, possibly caused by the Fraser River breaking through a dam of the Lower Lavas. This feature of coarse tilted gravel overlying Australian members (a), is exhibited at other points subsequently mentioned.

About three quarters of a mile down-stream from the Cariboo Syndicate's shaft is an outcrop of well-lithified steeply-dipping conglomerate beds, which is believed to exemplify sediments of the pre-volcanic southerly-flowing Fraser River, and is described under "Tertiary Fraser River Sediments."

Ahbau Creek a quarter of a mile above the junction of Horn Creek, emerges from a rock-walled canyon. The total depth of incision in the plateau-like region at this point is about 400 feet, and rock is exposed to a height of 200 feet above the creek. The rock exposed at the lower end of the canyon is volcanic breccia which is intruded by tongues of fine-grained acidic rock.

The Cottonwood River is crossed by a bridge on the Prince George-Quesnel highway at the lower end of a steep-walled rock canyon. The rocks exposed at this point are volcanic flow-rocks probably Mesozoic in age.

Herrick-McGregor River Valley

The southwesterly-flowing parts of Herrick Creek and the McGregor River occupy one and the same valley, which for brevity is called in this report the "Herrick-McGregor River Valley." Burnt Mountain lies to the west of the junction of Fontoniko and Herrick Creeks (Fig. 3) and the elevation of its summit is 5,910 feet. In the central part of this mountain is a glacial cirque, the floor of which is at elevation 4,915 feet and the walls can be readily climbed. As far as could be determined, all slopes of this mountain drain into Fontoniko or Herrick Creeks. Immediately to the west is another higher mountain separated from Burnt Mountain by a deep valley (Fig. 3). The Arctic-Pacific Divide passes over the summit of this high mountain, (the elevation of which appeared to be over 6,500 feet) the drainage of its south-eastern slopes being into Fontoniko and Herrick Creeks, and that of its northern slopes into the upper reaches of the Parsnip River. Viewed from Burnt Mountain, the pronounced synclinal structure of the upper part of this high mountain was plainly evident.

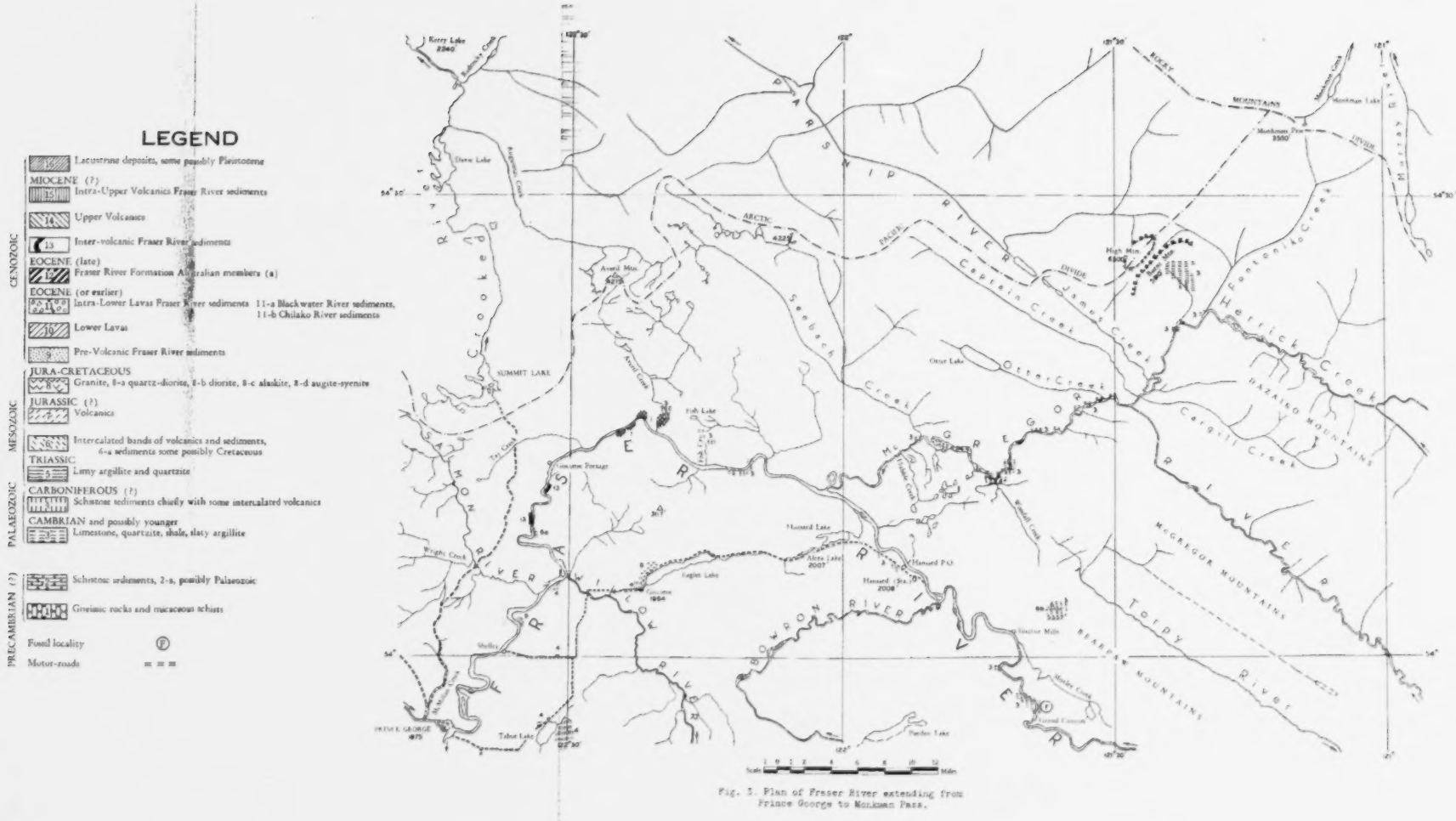


Fig. 3. Plan of Fraser River extending from Prince George to Monkman Pass.

The lower slopes of Burnt Mountain are covered with dense vegetation and timber-growth up to elevation 3,215 feet, above which a bush-fire passed many years ago. On the lower slopes and at the base of the mountain, rock-outcrops emerge at several points. These outcrops comprise schistose quartzite and thinly-bedded argillite, strike from north 53 to 72 degrees west, dip about 45 degrees south-westward. From the floor of the glacial cirque to the summit, the formation where exposed on the northern side consists of schistose limestone, strike north 43 degrees west dip 60 degrees north-eastward.

Save in the canyon, rock-outcrops are few, close to the river in the Herrick-McGregor River Valley. About 3 miles above James Creek on both banks of Herrick Creek dolomitic limestone outcrops, strike north 52 degrees west, dip 65 degrees south-westward. Near the mouth of Otter Creek, mainly down-stream from this point for a distance of somewhat over 1 mile, are four rock-outcrops consisting of crenulated argillite, and thinly-bedded quartzite. These rocks strike from north 22 to 77 degrees west and dip north-eastward at steep angles. At 7 1/2 miles below the junction of the northwesterly-flowing part of the McGregor River on the northern bank interstratified, fine-grained quartzite and argillite strike north 72 degrees west and dip 70 degrees southward. One mile down-stream from the last exposure, on the northern bank of the river, is an outcrop of limestone, at some points thinly-bedded, at others massive. About 24 miles above its mouth the McGregor River enters a rock-canyon. A gap in the canyon about half a mile in length, at about three-fifths of a mile above the lower end, divides the canyon into two sections; a down-stream section three-fifths of a mile in length, and an up-stream section somewhat less than 2 1/2 miles in length. The height of the walls of the canyon varies from 30 feet to about 75 feet. In the up-stream section, describing the outcrops in their order from the head of the canyon down-stream:

(1) fissile, thinly-bedded, interstratified argillite and limestone strike north 29 degrees west and dip 75 degrees south-westward,

(2) one mile down interstratified argillite and quartzite contain irregular and discontinuous quartz lenses of maximum width 2 1/2 feet, which follow the bedding-planes of the host-rocks. These rocks strike north 47 degrees west and dip 65 degrees north-eastward,

(3) at a point 1 1/2 miles down, differential weathering has formed a pillar 20 feet high of much fractured quartzite containing resistant quartz gash-veins. The quartzite strikes north 42 degrees west and dips 75 degrees north-eastward,

(4) immediately adjoining down-stream, fissile blue and cream-coloured limestone much drag-folded and containing numerous calcite veins is interstratified with quartzite. The formations strike north 12 to 22 degrees west. The dip at some points is 55 degrees south-westward, at others 70 degrees north-eastward.

The lower section of the canyon is incised wholly in quartzite. The beds vary from 3 to 12 inches in thickness with argillaceous partings, which are the cause of differential weathering at some points. The strike varies from north 42 to 57 degrees west with dips varying from 75 degrees north-eastward to nearly vertical.

Eight miles below the canyon on the northern bank of the McGregor River, lime schist is exposed, strike north 27 degrees west, dip 60 degrees south-westward. At this point the planes of schistosity strike north 42 degrees west cutting the bedding planes.

The rocks exposed in the Herrick-McGregor River Valley resemble those exposed at the lower end of the Grand Canyon.

Nechako River Valley

Only the lower 13 miles of the Nechako River Valley was examined in detail. Because of the existence of the Lower Lavas at certain other points, and the evidence of damming by them, an examination was made of this river at two up-stream points namely at the Isle de Pierre Rapids and White Mud Rapids, and also of a region near the mouth of its large tributary, the Chilako River. These lavas are mainly of basaltic composition and some of the outcrops are large. Reasons for correlation with the Lower Lavas are:

(a) All outcrops are of the valley-fill type in contradistinction to the topographic position of the Upper Volcanics which normally cap the valley-rims and form the floor of the Interior Plateaux.

(b) The angle of inclination of the separation planes between successive lava-flows is generally much steeper than in the case of the Upper Volcanics.

(c) The outcrops frequently are deeply weathered which is a feature foreign to the Upper Volcanics.

(d) In one instance, described subsequently, lava eruption was undoubtedly contemporaneous with the deposition of beds of fossiliferous diatomaceous silt. Palaeontological evidence in this case indicated an Upper Eocene or Oligocene age. In the Horsefly and Kamloops areas the end point of the Lower Lavas is indicated by the emission of enormous quantities of ash in late

Eocene time, which continued into the Oligocene. In the Nechako and Chilako River Valleys apparently lava eruption continued during the period of ash-emission in the southern regions.

Isle de Pierre Rapids. These rapids may be readily reached by a branch motor-road 6 1/2 miles in length which leaves the highway at a point 32 miles west of Prince George.

Near the Isle de Pierre Rapids (Fig. 2) the river flows due south and occupies a valley of mature relief considered as a whole, although banks of unconsolidated material rise sharply from near the river. The Isle de Pierre Rapids, somewhat over three-quarters of a mile long, incise the Lower Lavas, which occur as a typical valley-fill, and rock is exposed up to points about 50 feet above the river. The valley-rims are not steep close to the river. Above the rock exposures the valley-slopes are covered with dense vegetation and timber growth. Here the Lower Lavas consist of basaltic flows, breccias, and agglomerates strike north 11 degrees east and dip about 45 degrees westward. Locally they are deeply weathered.

It is apparent that originally the Nechako River must have been obstructed or dammed at this point by the eruption of these lavas.

White Mud Rapids. These rapids are about 1 1/4 miles down-stream from Bednesti Station. A car may be taken to the top of the south valley-rim directly above the rapids by following a branch-road about 3 miles in length from the Chilako road. The latter leaves the highway 15 miles west of Prince George. The total distance by road from the latter place to the rapids is about 23 miles. On the southern bank of the river, on the Canadian National Railway right-of-way, 25 feet above the river, about 1 mile east of Bednesti Station at several points in a distance of half a mile, are outcrops of Lower Lavas. These are andesitic in composition and strike about north 12 degrees west and dip about 40 degrees eastward. The lavas are deeply weathered and the outcrops have been converted into masses of white and red-coloured residual clay. Reducing acids resulting from decomposition of vegetable matter have doubtless been active in decolourizing the clay. Presumably these rapids owe their name to the deposits of white clay in this region. Thinly-bedded limy shale of possible Mesozoic age outcrops between the exposures of Lower Lavas on the railway.

The river cuts through older rocks, exposing in its bed massive pyritized andesite of possible Mesozoic age, somewhat down-stream from the most easterly exposure of the Lower Lavas. Schistose carbonaceous argillite, strike north 47 degrees west, dip 75 degrees north-eastward is exposed 300 yards up-stream from the andesite on the southern bank of the river.

A detailed account of the lower 13 miles of the Nechako River Valley follows:

At Canadian National Railway Mile-post 13 (13 miles west of Prince George) a small creek flowing north-westerly enters the southern bank of the Nechako River (Fig. 2). Near the river for a length of 300 feet the creek has cut down to a maximum depth of 85 feet, through 20 feet of unconsolidated glacial and post-glacial materials overlying beds of compacted argillaceous diatomaceous silt 65 feet in thickness. The lowest beds exposed are black, while those at the top of the exposure are shiny black, except on the southern side of the creek where cut by the railway-grade 55 feet above the Nechako River, the colour is greyish-white. These last proved fossiliferous, and specimens were sent to the Palaeontological Section, Department of Mines and Resources, Ottawa. Dr. Walter A. Bell, Chief, Palaeontological Section reports as follows: "Except for one or two indeterminate stems the fossils consist of a single species of dicotyledonous leaf, identified as Sapindus sp. Dawson. Dawson's type specimens of this species seemingly were collected from Blackwater River, so with little doubt from the same formation. Sapindus is perhaps a doubtful reference, for the species is much like some of the live oaks. The light-grey siltstone in which the leaves are embedded is quite diatomaceous, and the leaves are very well preserved showing most details of the venation. The age of the formation cannot of course be defined from a single species, but undoubtedly is of the same Tertiary age as the plant-bearing beds of Quesnel, presumably Upper Eocene or Oligocene."

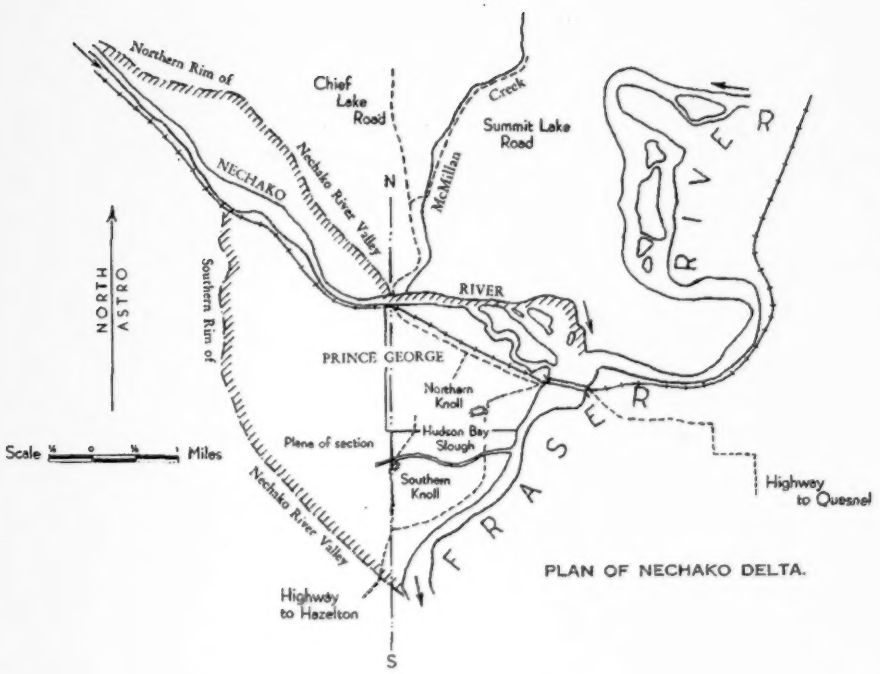
The lower beds of siltstone in place appear almost black, but on drying, the colour changes to grey. At the lowest point of exposure of the siltstone beds, 20 feet above the river, chloritized basalt of the Lower Lavas outcrops and underlies the siltstone beds. Farther up the creek numerous small dykes a few inches in thickness intrude the siltstone beds, and numerous small bombs occur in the bedding planes of the siltstone. On the northern bank of the creek near the railway-cutting is an intercalated scoriaceous bed of lava 4 feet thick exposed for a length of 10 feet. It is apparent from the exposures that volcanism was in progress during the deposition of the siltstone beds. The attitude of the siltstone is poorly defined. At the lower end of the exposure, below the railway, where a small bed of fine gravel 15 inches thick is interstratified with the siltstone beds, the strike is north 58 degrees east, and the dip about 30 degrees south-eastward. At the upper end of the exposure, on the northern side of the creek, the siltstone, which is here not diatomaceous, strike north 12 degrees west, and dip 45 degrees south-westward, is intruded by dykes of basalt about 2 feet wide.

Distant 220 feet in a north-easterly direction from the mouth

of the creek described on the southern bank of the Nechako River, a bed of lignite 6 feet in thickness, strike north 42 degrees east and dip 35 degrees south-eastward, is exposed at river-level for a distance of 70 feet along its strike. This bed is overlain by clay beds of an exposed thickness of a few feet. Distant 340 feet in a north-easterly direction from the lignite is another bed of an exposed thickness of 5 feet, of similar strike and dip partly covered by water at the time of examination. This is traceable for a distance of 60 feet along its strike, and is stratigraphically lower than the first bed. It is directly underlain by beds of carbonaceous shale, and grey and black non-diatomaceous siltstone. Chloritized basalt of the Lower Lavas outcrops for a length of 150 feet at the river's edge, 525 feet up-stream from the mouth of the creek.

Three-eighths of a mile to the north of this creek, a large outcrop of Lower Lavas occurs to the east of the railway-cutting, 60 feet above the Nechako River, and smaller outcrops were observed at points in the railway-cutting between this point and Miworth. Although the actual contact is not exposed, there can be but little doubt, in view of the close proximity of the exposures to one another that the lignite seams and the beds of shale, siltstone and clay containing them directly underlie the diatomaceous and fossilferous siltstone beds. These described exposures indicate that the Nechako River was dammed by the eruption of Lower Lavas, and that the lignite and siltstone deposits were laid down in a basin resulting from damming, and also that volcanism continued during the period of their deposition.

Two miles down-stream from Miworth, the Nechako River changes its direction of flow from north-easterly to south-easterly. In this region a feature of the river is the extensive terraced delta-like area which extends to its junction with the Fraser River at Prince George. This delta-like area is bounded on the northern and southern sides by high valley-rims (Fig. 4) where its width is 3 3/4 miles. On the northern side of the river gravel, silt, sand and clay banks rise to a height of from 340 to 465 feet above the river, but no rock-outcrops occur near the river. On the southern side on the other hand, the rim bounding the delta-like area is composed for a length of 6 1/2 miles wholly of rock, and rises to a maximum height of 675 feet above the river to the plateau-level. To the south, this rim continues to its mergence with the Fraser River Valley. To the north near Otway the height of the rim decreases. On the south side of the river between Otway and Miworth on the Canadian National Railway right-of-way 55 feet above the river, are frequent rock-outcrops, which suggest that the covering of glacial debris may be thin and that a rock-rim may be continuous between these points. The rocks forming the high rim on the southern side of the Nechako River are schistose greenstone, quartz-chlorite schists and thinly-bedded carbonaceous



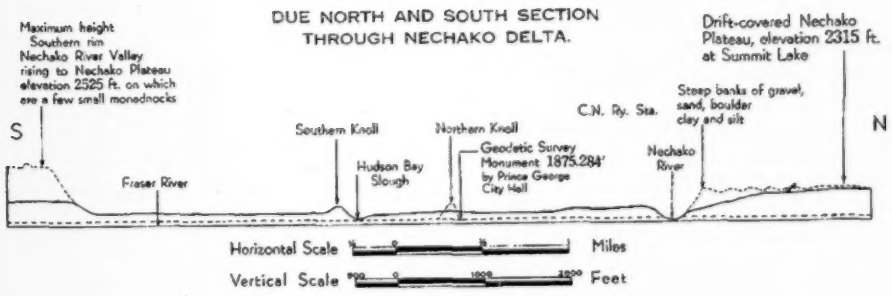

DUE NORTH AND SOUTH SECTION THROUGH NECHAKO DELTA.
Maximum height Southern rim Nechako River Valley rising to Nechako Plateau elevation 2525 ft. on which are a few small monadnocks
Drift-covered Nechako Plateau, elevation 2315 ft. at Summit Lake
Steep banks of gravel, sand, boulder clay and silt
C.N. Ry. Sta.
S
N
Southern Knoll
Northern Knoll
Geodetic Survey Monument 1875.284' by Prince George City Hall
Hudson Bay Slough
Nechako River
Fraser River
Horizontal Scale ½ 0 ½ 1 Miles
Vertical Scale 500 0 1000 2000 Feet

Fig. 4

Fig. 4. Plan of Nechako River Delta.

argillite, striking from north 17 to 22 degrees west, dips mostly steep and not less than 75 degrees westward. Occasional strikes to the north-east were observed. This assemblage is intruded by a stock or cupola of batholithic rock of considerable size at the northern end, phases of which are granite, alaskite, and diorite. Reference to mineralization in these rocks will be found in the Annual Report of the Minister of Mines, British Columbia, 1926 under "Largeasse." To the west of the high rock-rim, these rocks compose knolls on the Nechako Plateau, evidently erosion remnants, or monadnocks. On the Canadian National Railway right-of-way half a mile west of Otway, pyritized limestone underlying quartz-chlorite schist is intruded by alaskite tongues several feet in width. The intruded rocks strike due north and dip 35 degrees west. Half a mile west of the last-described exposure in the railway-cutting, quartz-chlorite schist, strike north 67 degrees west, dip 35 degrees south-westward, is intruded by alaskite tongues varying from a few inches to 3 feet in width.

Immediately east and west of Miworth station, and on the east side of the motor-road below the station, chloritized and carbonatized schistose rocks strike north 3 degrees east, dip 50 degrees eastward, are exposed over a considerable area.

On the north side of the river between Miworth and Prince George, search failed to reveal any rock-outcrops. On this side of the river, the nearest known rock exposure in this section is on Pilot Mountain, about 2 miles south-westerly from Swamp Lake. The elevation of the summit of this mountain is 3,275 feet or about 960 feet above the plateau. Partly argillaceous and schistose quartzite is exposed a short distance below and at the summit of this mountain, strike from north 22 to 48 degrees east, dip 50 degrees north-westward. Quartz veins were observed in the quartzite.

The Chilako River was examined at points between 1 mile and 2 miles above its junction with the Nechako River, and the evidence obtained clearly indicated damming of this river by eruption of Lower Lavas. In this region three points were observed at which the river cuts through the sediments of its Tertiary channel intercalated with flows of pillow-lava of the Lower Lavas. Distant about three-quarters of a mile from the mouth of the river on the east bank, one such exposure (overlain by 15 feet of glacial debris) is 150 feet in length and 90 feet in height. At this point the intercalated beds of sandstone and pillow-lava are in places horizontal, and in other parts of the exposure dip about 15 degrees eastward. One hundred yards up-stream on the west bank of the river is another somewhat similar exposure. About one mile farther up-stream on the east bank of the river is a cliff-like exposure of extremely vesicular basaltic lava, 70 feet high and 200 feet long. At some points are intercalated horizontally

stratified beds of sandstone and diatomaceous material a few inches in thickness. Distant one hundred yards to the east of this exposure on the east rim of the valley of the river are well-stratified volcanic breccias. These are horizontal, and are deeply weathered. Immediately to the north of these breccias is a large knoll composed of fine-grained basalt of the Lower Lavas. The separation planes between successive flows strike due east and dip 15 degrees north.

TERTIARY FRASER RIVER SEDIMENTS

In classification as "pre-volcanic" the following criteria are deemed essential:

(a) Entire absence of constituent grains or pebbles composed of Lower Lavas or younger rock-formation.

(b) Likelihood of strata being tilted as considerable movement is known to have taken place subsequent to eruption of the Lower Lavas.

(c) Rocks of this age will be well-lithified.

Pre-volcanic Fraser River

Sediments of this river were found at three widely-separated points:

(a) On the east bank of the Fraser River about 10 miles south of Quesnel for approximately 1 1/4 miles up-stream from Sisters Creek.

(b) On the east bank of the northerly-flowing part of Canyon Creek nearly due east from Whites Landing.

(c) On the east bank of the Fraser River about 3 miles to the north-east of Shelley (Fig. 3).

A description of each of these exposures follows:

(a) This exposure may be reached from the highway at a point 10 miles south of Quesnel where the Fraser River flows a few hundred yards from the highway.

At this point over a length of 750 feet and height of 220 feet, beds of alternating interstratified conglomerate and sandstone are exposed at the river's edge. These strike north and dip from 25 to 30 degrees east. Owing to differential weathering, the exposure is pinnacled and as it rises sheer from the river's edge its scenic aspect is impressive. The pebbles in the conglomerate range from 1/4-inch to 7 inches in diameter and are composed of diorite, granodiorite, and schistose andesitic lava. Although poor sorting is evidenced, imbrication is distinct and indicates that the water in which these sediments were deposited flowed southerly. The exposure is overlain by about 10 feet of post-glacial and glacial material. In the upper part of Dog Prairie Creek, a small stream flowing westerly into the Fraser River at a point 1 1/2 miles up-stream from Sisters Creek, the top of these sediments is exposed, and there they are considerably

weathered and are stained a deep-red colour. This is probably a preserved remnant of Tertiary weathering.

(b) The exposure is reached by following a branch motor-road, which leaves the highway 36.8 miles north of Quesnel, and crosses to the east side of Canyon Creek. The bridge across Canyon Creek is a little more than half a mile from the highway and the exposure is about 300 yards downstream from the bridge.

At this point steeply-dipping, well-lithified beds of conglomerate, sandstone and silt are exposed for a length of 250 feet over a height of 25 feet. These are unconformably overlain by 100 feet of well-sorted horizontally-stratified gravel. Overlying the latter is 60 feet of glacial material including boulder-clay with a considerable thickness of silt in the upper part.

The steeply-dipping conglomerate, sandstone and silt beds contain some carbonized driftwood and some lignitic clay seams. They strike north 27 degrees west and dip steeply south-westward. The pebbles in the conglomerate range from 3 to 6 inches in diameter and are derived from batholithic rocks, quartzite, grey-black cherty quartzite, argillite and andesite. At least 25 per cent. of the pebbles are composed of batholithic rocks. No pebbles derived from Tertiary volcanic rocks are present. These strata show evidence of considerable movement along the bedding-planes.

The well-sorted horizontally-stratified gravel which overlies the steeply-dipping beds may be of interglacial age.

(c) The exposures may be readily reached by walking along the Canadian National Railway line north-easterly from Shelley station.

Well-lithified beds of sandstone overlying conglomerate are exposed in the railway cutting at Mile-post 133 (133 miles west of McBride), 3.3 miles north-east of Shelley station. The length of this exposure is 270 feet and the maximum height on the east side of the railway-cutting is 40 feet. The elevation of the railway above the Fraser River at this point is 35 feet.

The beds strike north 54 degrees east and dip from 25 to 30 degrees north-westward. The pebbles in the conglomerate range from 4 to 10 inches in diameter and are largely composed of hard resistant rock. The majority are grey quartzite, but a proportion, possibly ten per cent. of the total, are composed of a greyish-white, feldspathic rock now kaolinized. Imbrication suggests a southerly flow. Unfortunately no fossils were found in this exposure, and although the beds contain a small amount of silicified driftwood, the state of preservation of a specimen submitted to the Palaeontological Section of the Department of Mines and

Resources Ottawa proved too poor for determination of age. The degree of lithification suggests an early Tertiary if not late Cretaceous age.

Distant 300 yards to the south-west of the above exposure on the east rim of the Fraser River Valley which rises immediately east of the railway-line, sandstone beds overlying conglomerate beds are exposed over a length of 250 feet. The top of this exposure is 75 feet, and the bottom 25 feet, above the railway, but dense vegetation somewhat obscures the exposure. At this point the beds strike north 8 degrees east and dip about 10 degrees westward and the exposure may be near the top of an anticlinal fold. At 25 feet above the railway an old adit has been driven in the conglomerate beds for 63 feet on a bearing south 37 degrees east. Samples from this adit assayed nil in gold, but this horizon is certainly many feet above the bed-rock of the channel. In this adit the pebbles range in diameter from 2 to 8 inches, and the majority are of grey quartzite. Imbrication, although not conclusive, indicates a northerly flow of water. Half a mile to the south-west of the first-described exposure on the east side of the railway-cutting is an outcrop 30 feet long by 10 feet high mostly of sandstone with a conglomerate lens.

At a point 2 1/2 miles up-stream from Shelley conglomerate beds are exposed at and below river-level for a length of about 50 feet. The extent of the beds at water-level cannot be ascertained owing to the accumulation of sawdust from a nearby sawmill. Quite possibly search on the east rim of the Fraser River Valley to the south-west of this conglomerate would reveal extension of these beds.

It is apparent that the described exposures are those of a deeply-entrenched river of large proportions and distant headwaters. The position is likely close to the former junction of the Nechako River and the northerly Fraser River drainage. As the exposure does not afford a section near bed-rock, it is not possible to gain information as to the terrain reached by the headwaters. Moreover, but little information as to the direction of flow can be gleaned from the pebbles contained in the conglomerate beds. These pebbles are largely derived from a resistant rock, quartzite, which indicates flow for a lengthy period, but as quartzite is exposed near the Fraser River to the south of this point as well as to the north on the Fraser and Herrick-McGregor Rivers (see "Bed-rock Geology"), obviously evidence of direction of flow is inconclusive, as is the conflicting imbrication at different points. The deep incision may suggest a southerly flow of water, and conflicting imbrication may possibly be due to eddy currents due to junction of the Nechako and Fraser Rivers. Noteworthy is the absence of pebbles derived from nearby rocks such as the schistose greenstone exposed about 3 miles

to the north, or the micaceous schists at the north bend of the Fraser River. The latter are of resistant character, but the former are less resistant than quartzite. The grey kaolinized feldspathic pebbles which are present to a small extent in the conglomerate might conceivably be derived from granitic rock, which occurs near Eaglet Lake, and also to the south at the northern end of the range between the Fraser and Willow Rivers, and in the south rim of the Nechako River Valley near Prince George.

Intra-Lower Lavas Fraser River

Exposures of sediments of this river are given in British Columbia Department of Mines Bulletin No. 3, 1940, an additional exposure was discovered during the year, which is of particular value, as the age is supported by palaeontological evidence.

This exposure is on the west side of Baker Creek 2 1/2 miles up-stream from its mouth and may be a preserved remnant of the down-stream continuation of the river-channel on the placer claim of R. Blair (see Annual Report of the Minister of Mines, British Columbia, 1938, pp. C36 to C39). It is 1,600 feet north 46 degrees east from the latter.

At this point an isolated outcrop about 200 feet long, of white quartzite, rises sharply from the water's edge on the west side of Baker Creek to a height of 80 feet above the creek. The upper 40 feet of the quartzite is much decomposed and is directly overlain by a total thickness of about 12 feet of thin beds of tuffaceous grit, gravel and clay. A flow of the Lower Lavas 3 to 4 feet thick, extensively kaolinized, of a salmon-pink colour, caps the exposure. The lava flow is directly overlain by soil and a little glacial debris. Some of the beds of grit contain small seams of lignite, and in one bed is a veinlet of fibrous barite about 3/4-inch thick. The following section is given at the highest point of the exposure: soil 2 feet; lava-flow, 3 to 4 feet; tuffaceous grit-bed (with small seams of lignite and veinlet of fibrous barite 3/4 inch thick) 6 to 8 inches; gravel bed from 15 inches to 4 feet containing pebbles 2 inches in diameter composed mainly of schistose quartzite and argillite with some quartz; tuffaceous grit-bed, 9 inches; bluish-coloured clay with seams of lignite, 4 feet; decomposed and kaolinized rock, apparently mainly quartzite, but some decomposed lava may also be present, 40 feet; quartzite to creek-level, 40 feet.

The sediments strike north 52 degrees west and dip 15 to 20 degrees north-eastward.

At the northern end of this exposure the beds of tuffaceous grit contained fossil leaves. The following section was exposed: at the top, soil, 1 foot, kaolinized, red-coloured lava-flow, 3

feet; tuffaceous grit-bed, 6 inches; gravel-bed, 15 inches; tuffaceous grit-bed, 9 inches; gravel-bed, 9 inches; tuffaceous grit-bed, 2 feet; gravel-bed, 9 inches. The region immediately below is obscured by vegetation but quartzite outcrops in the creek below.

Specimens of the fossiliferous grit-beds were submitted to the Palaeontological Section, Department of Mines and Resources. Dr. Walter A. Bell reported as follows: "The leaves are too broken to be identifiable. Seemingly they represent a species of birch (Betula) like Betula macrophylla Heer. The age I think is probably Upper Eocene or Oligocene."

Exposures of Tilted Coarse Fraser River Sediments Immediately Overlying Australian Members (a) of Fraser River Formation

Although beds of sand, clay and fine sub-angular gravel interstratified with lignite beds form the Australian members (a) of the Fraser River formation in most cases, at some points exposures of gravel are of such a thickness and the constituent pebbles so large, from 4 to 10 inches in diameter, as to indicate that before tilting of Australian members (a) the flow of the Fraser River was restored over the basins in which the lignite deposits were formed. To avoid undue complexity, these sediments are mapped as Australian members (a) (Figs. 1 and 2) and not as separate Fraser River sediments. Extensive exposures of the type indicated occur on both sides of the Fraser River at the water's edge to the north of Dog Prairie Creek 7 miles south of Quesnel, and also on Canyon Creek (previously described).

On the west side of the Fraser River somewhat north of a point opposite Dog Prairie Creek, four seams of lignite and interstratified clay beds of a total thickness of 17 feet, are overlain by 100 feet of gravel. The strike is north 40 to 77 degrees west and the dip 20 to 40 degrees south-westward. The horizontal length of this assemblage is 350 feet and the vertical height 85 feet. These tilted strata are unconformably and directly overlain by 14 feet of boulder-clay and glacial gravel. The glacial material is overlain by 20 feet of horizontally-stratified post-glacial river-silt.

On the east side of the Fraser River opposite, and up-stream from the last-described exposure, are extensive outcrops of gravel beds strike north 22 degrees west and dip 40 degrees north-eastward. At the up-stream end these gravels conformably overlie beds of lignite and clay. The maximum height of these exposures is 75 feet above the river, and they are unconformably overlain by post-glacial beds of gravel and silt a few feet in thickness. To avoid undue complexity, however, such sediments are not classified separately.

Inter-Volcanic Fraser River

Sediments of this formation are exposed at Giscome Rapids and at a point 5 miles north of Quesnel. (Figs. 1, 2 and 3). Numerous exposures east of the Fraser River Valley, between those on Canyon Creek and those near the mouth of the Cottonwood River, prove that the inter-volcanic Fraser River occupied a valley considerably to the east of the present Fraser River Valley in this region. This ancient valley was bounded on the west by the rock-exposures trending from Lazaroff Lake in a north and south direction immediately west of Whiteslanding Creek. The rock-outcrops on both sides of the Fraser River between the Cottonwood Canyon and the mouth of the Cottonwood River are the most southerly exposure of the west rim of this valley. The valley is bounded on the east by high-lying rock-exposures on Government, Hixon, Terry and westerly-flowing part of Canyon Creek, by the rock-canyon on Ahbau Creek and that on the Cottonwood River at the highway-crossing. Exposures of sediments on the Cottonwood River comparatively close to those at the double hairpin bend of the Fraser River 10 miles north of Quesnel, even allowing for meanders, indicate a river of great width.

Between the exposures of the sediments of the inter-volcanic Fraser River on Canyon Creek and the Giscome Rapids, there is a long gap. Considering the topography of this part of the Fraser River in conjunction with the form and geographic distribution of rock-outcrops, there is every reason to believe that up-stream from Woodpecker Island the course of the pre-volcanic southerly-flowing Fraser River and all subsequent Tertiary channels of the Fraser River deviated but little from that of the present Fraser River. There is little doubt that between Canyon Creek and Woodpecker Island, the course of the inter-volcanic Fraser River lay immediately east of the high rock-rim which is continuous on the east side of the Fraser River in this region.

Below Canyon Creek exposures prove that for a short distance the course of the inter-volcanic Fraser River coincided with the Fraser River. Exposures on Whiteslanding Creek prove that the course of the former river was approximately due south of Whites Landing within the ancient valley.

The exposures of sediments of the inter-volcanic Fraser River are mainly large, such as those at the double hairpin bend of the Fraser River 10 miles north of Quesnel; on the east bank of the Fraser River above Whites Landing and on both banks of Canyon Creek, down-stream from the junction of Hixon Creek and on Ahbau Creek. Some of these are close to half a mile in length and the height exceeds 200 feet. The impressive size of these exposures suggests the long life of the river and the enormous amount of erosion accomplished by it. The nature of the pebbles indicates that far headward erosion was accomplished by this river.

Distinctive features of these sediments are:

(1) The strata are horizontal or nearly so.

(2) The pebbles in the lowest gravels range in size from 6 to 8 inches, and are derived from resistant rocks such as grey and garnetiferous quartzite, and gneiss. These rocks are exposed up-stream from Giscome Canyon except the last which is known to occur near Tete Jaune. Imbrication is pronounced and in all cases indicates a southerly flow. Lithification is well advanced.

(3) The size of the pebbles decreases from the base upwards and the uppermost beds in some exposures consists of sand or clay.

The foregoing features are common to all exposures. In some there are thick beds of white or cream-coloured clay indicating approach to lacustrine conditions. The cream-coloured clay found at a point on the Fraser River 25 miles up-stream from Prince George, is suitable for the manufacture of high-grade refractories. As in some instances, beds of lignite overlie the clay, doubtless the purity of the latter is due to the reducing action of the former on percolating waters containing iron in solution.

The locations of exposures of sediments of the inter-volcanic Fraser River are shown on (Figs. 1, 2 and 3).

(a) Half a mile below Whiteslanding Creek on the western bank of the Fraser River is an exposure of particular diagnostic value. There a thickness of 35 feet of typical inter-volcanic Fraser River sediments is immediately underlain by 10 feet of sediments of the Tertiary West Road River at river-level. The inter-volcanic Fraser River sediments are directly overlain by 4 feet of post-glacial gravel, which is again overlain by 4 feet of river-silt. The total length of this exposure is 350 feet and the height about 50 feet. The sediments of the Tertiary West Road River are quite distinctive owing to the number of pebbles of grey-black cherty quartzite present. This exposure is of particular value in proving that the West Road River joined the inter-volcanic Fraser River near this point, and that drainage in the former was reversed subsequently.

(b) On the west bank of Whiteslanding Creek, half a mile above its junction with the Fraser River, are two exposures of sediments of the inter-volcanic Fraser River, 60 feet apart; the distance between them is covered by vegetation. Their average height is 125 feet, and the length of one exposure is 80 feet and the other 150 feet. The gravel beds at the base of these exposures show pronounced imbrication, indicating southerly flow of the stream depositing them. The pebbles range in diameter from 4 to 6 inches, and although mainly derived from grey quartzite, show a commingling

with the grey-black quartzite characteristic of the gravel of the Tertiary West Road River. At one point a dark-coloured stratum in the gravel, 6 inches thick, contains much secondary pyrite.

(c) At the lower end of Whiteslanding Creek Canyon on the top of the east canyon-wall, 130 feet above the bed of the creek, a thickness of 11 feet of sand and fine gravel contains at the base a seam of lignite 5 inches thick, overlain and underlain by white clay a few inches in thickness. The lower clay is underlain by beds of sand and gravel of a total thickness of 20 feet which rest directly on bedrock forming the canyon-wall. A number of the constituent pebbles in the gravel are grey-black quartzite. This exposure is directly and unconformably overlain by an exposed thickness of 60 feet of boulder-clay and glacial material. Higher points are concealed by vegetation. A near approach to lacustrine conditions and also commingling of the Tertiary West Road River and the inter-volcanic Fraser River are indicated.

(d) A number of exposures of sediments of the inter-volcanic Fraser River occur on Ahbau Creek between the lower end of the canyon and the junction of the creek with the Cottonwood River, and from that point along the Cottonwood River to its junction with the Fraser River. This indicates very plainly that the inter-volcanic Fraser River was deflected south-easterly at Ahbau Creek canyon by the rock at that point and at the canyon on the Cottonwood River.

Exposures on Ahbau Creek have added interest because most of the sediments of the inter-volcanic Fraser River are overlain by boulder-clay, which is again immediately overlain by varved clay. The significance of the latter has been previously discussed under "Glacial Geology." Its presence here is indicative of the size of the lake occupying the Fraser River Valley following the final disappearance of ice and prior to restoration of drainage.

On the eastern bank of Ahbau Creek, 1 1/2 miles above Cinema, sediments of the inter-volcanic Fraser River are exposed over a length of 150 feet and height of 55 feet. The exposure consists of well-sorted imbricated gravels with a lens of sand, and is directly overlain by 4 feet of boulder-clay on top of which rests 6 feet of stratified silt. Distant 150 yards up-stream is a larger exposure 250 feet long and 150 feet high. At this point the section of the total exposure is as follows: on top underlying dense timber-growth, silt 15 feet; varved clay, 30 feet; stratified silt, 20 feet; boulder-clay and glacial gravel, 40 feet; sediments of inter-volcanic Fraser River consisting of well-sorted gravel, 45 feet, extending to creek-level.

Large exposures of sediments of the inter-volcanic Fraser River also occur near the lower end of Ahbau Creek canyon a short

Plate I A. Pinnacle in Tertiary gravel of the inter-volcanic Fraser River at the Big Bend, 10 miles north of Quesnel.

Plate I B. Differential weathering in intra-Upper Volcanics - sediments lying between lava beds, near Macalister.

distance above Norn Creek. Near the lower end of the canyon there is a gap in the high rock-walls about 1,000 feet long, and in this gap are two large exposures of the river-sediments. Down-stream from these the rock-canyon continues for several hundred feet, but this part of the canyon is incised immediately to the east of the river-sediments which are again exposed immediately below the end of the rock-canyon.

At the upper end of the gap is an exposure of the river-sediments 300 feet long, and the following section is afforded: at the top underlying timber-growth and soil, silt, 5 to 10 feet; varved clay, 5 to 15 feet; boulder-clay, 25 feet; well-sorted imbricated gravels lithification of which is well advanced, 125 feet. The constituent pebbles range from 3 to 6 inches in diameter and are derived mostly from grey quartzite and garnetiferous quartzite. Another exposure 300 feet down-stream shows considerable cross-bedding. This region is probably just at the point at which the direction of flow in the river changed from southerly to south-easterly, and cross-bedding is to be expected.

(e) On the eastern bank of the Fraser River 1 1/2 miles below Giscome Portage, sediments of the inter-volcanic Fraser River are exposed for a length of 300 feet, and the following section is afforded: at the top, soil, 2 feet; varved clay, 25 feet; boulder-clay and glacial gravel, 20 feet; well-sorted coarse gravel, 10 feet; yellow sands and clays, 40 feet; sediments of the inter-volcanic Fraser River mainly coarse well-sorted gravels, 50 feet extending to river-level.

The pebbles range from 4 to 6 inches in diameter and about 70 per cent. are composed of sericitic gneissic rock, 20 per cent. are of purple-coloured quartzite, and the remainder of white quartzite and quartz. The gravels are horizontal and have a dead-white bleached appearance. The overlying yellow sand and clay and also the coarse gravel overlying the latter may be of inter-glacial age. Possibly some lignite beds, originally overlay the gravels of the inter-volcanic Fraser River and have since been eroded. The original presence of lignite beds might account for the absence of oxidation in underlying beds.

(f) Somewhat over 3 1/2 miles down-stream from the last exposure a deposit of white clay occurs which is believed to be the clay member frequently present in the sediments of the inter-volcanic Fraser River. The clay is at the base of an extensive densely-timbered bench which flanks the west side of the Fraser River, and is exposed at several points a short distance above river-level for a distance of about a quarter of a mile. No work has been done on the property for years and original open-cuts have sloughed badly. This clay is a high-grade china-clay type, and was examined by the writer in 1931, whose account with

analyses appears in "Non-Metallic Mineral Investigations" Report No. 4, 1932, pp. 17, 18 and 19, published by the British Columbia Department of Mines. This clay is also mentioned in Geological Survey Canada, Memoir 118, 1920, p. 72.

Intra-Upper Volcanics Fraser River

Large exposures of sediments of this river occur just below the Fraser Plateau near the top of the east rim of the Fraser River Valley to the east and north-east of Macalister. These are almost continuous for a distance of half a mile easterly from Macalister, and one isolated exposure is about three-eighths of a mile north-easterly from the same place. James M. Macalister kindly pointed out all exposures known to him. In this region the elevation of the Fraser Plateau is about 3,030 feet, or 1,620 feet above the Fraser River. The plateau here is drift-covered and near the edge slopes gently downward towards the top of the east valley-rim of the Fraser River, which is formed of characteristic cliff-like exposures of the Upper Volcanics. The exception is the isolated exposure lying north-easterly from Macalister in which the volcanics overlie the sediments, below which talus and vegetation obscure the valley-slope.

These exposures of river-sediments and associated stratified water-lain breccias are well-lithified and exhibit locally pronounced cross-bedding. Save in the case of the isolated exposure north-easterly from Macalister, exposures are large, exceeding one hundred feet long and fifty feet high. The sediments are in most cases directly overlain by pillow-lava, and underlain by highly vesicular basaltic lava. The following is a typical section:

	Thickness in Feet
Top of east rim of Fraser River Valley	
Columnar basalt	100
Pillow-lava	20
Sediments - constituents range in size from grains less than an eighth of an inch to pebbles 3 inches in diameter - horizontal	20
Cross-bedded sediments and breccias	30
Basaltic vesicular lava - horizontal	50
Sediments - horizontal	15
Cross-bedded sediments and breccias	10
Vesicular basalt - horizontal	3 to 5 (obscurity due to vegetation and talus).

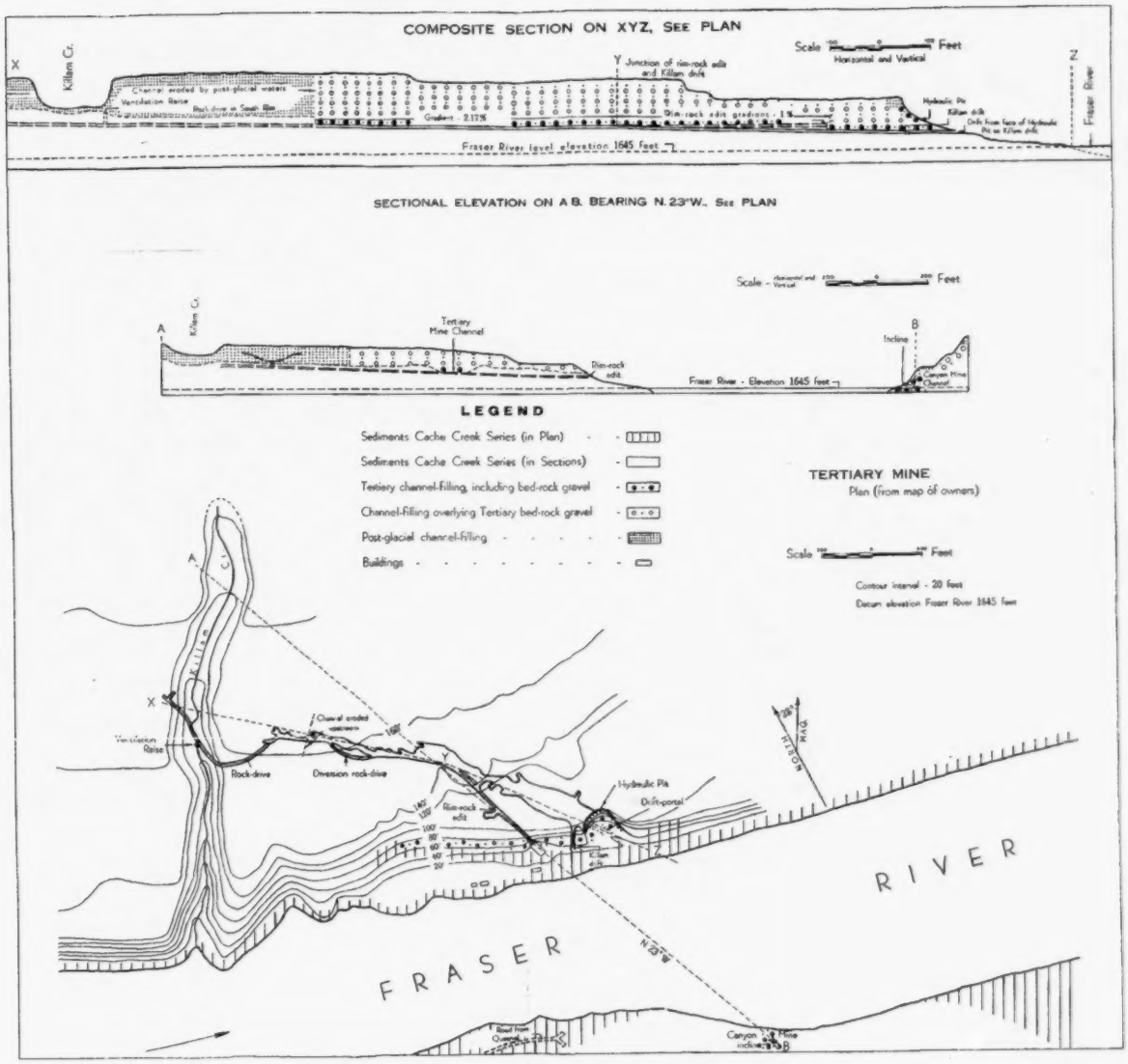


Fig. 5. Plan of the Tertiary Mine.

At one point differential weathering has formed a detached pillar, about 6 feet in diameter and 40 feet in height. This is composed of a capping of basalt 15 feet in thickness resting on 25 feet of slightly-inclined stratified sediments and breccias, which rests on lava (see Plate I B).

Tertiary Mine - Canyon Mine Channel

This examination suggests that this channel, exposed on both sides of the Fraser River at the Cottonwood Canyon and described in detail in British Columbia, Department of Mines Bulletin No. 3, 1940, pp. 22 to 27, is closely contemporaneous with the intra-Upper Volcanics Fraser River (Fig. 5).

There is much to suggest that this channel trends parallel to the Fraser River for some considerable distance north-west of the Tertiary Mine workings, British Columbia Department of Mines Bulletin No. 3, 1940. If so, it likely represents the Tertiary cutting of the down-stream part of the valley incised between the mouth of the West Road River and the mouth of the Cottonwood River. This valley was incised and drainage in the West Road River from the Tertiary mouth of this river to Whites Landing was reversed when the ancient valley to the east, formerly occupied by the Tertiary Fraser River up to and including the inter-volcanic Fraser River, was abandoned. This abandonment appears to have been due partly to the great accumulation of sediments in the ancient valley and partly to damming of the waters of the inter-volcanic Fraser River down-stream by eruption of the Upper Volcanics.

Sundry Additional Exposures

Owing to the criteria being insufficient to determine the age with certainty, the following exposures are grouped separately, and are not inserted on the geologic maps accompanying this report as indicating definite channels:

(1) The very coarse conglomerate and associated sediments exposed on Redrock Creek, 20 miles south of Prince George (Fig. 2) and described under "Bed-rock Geology," may represent a late Cretaceous channel of the Fraser River.

(2) Segments of former channels of the Fraser River of probable Pliocene age lie buried at the following points:

(a) On the east side of the Fraser River immediately up-stream from Diamond Island, near Alexandria Ferry, a segment of a Fraser River channel is incised in Australian members (a) of the Fraser River formation. The length of the segment is somewhat over a mile, but no gravel is exposed. The post-glacial waters

having swept over the up-stream part, left an extensive bench about 10 to 12 feet above the river, on which the drag-line dredge of North American Goldfields Limited is operating. At the down-stream end high glacial banks which overlie the west rock-rim of the channel gravel have not been removed by post-glacial waters and the channel filling is preserved for a length of 330 feet and height of 40 feet above river-level. This rim consists of Australian members (a) of the Fraser River formation.

The topography very strongly suggests that the up-stream continuation of this channel-segment lies buried in the west bank of the Fraser River to the west of Castle Rock, 2 miles up-stream from the last exposure.

(b) At the lower end of Fort George Canyon. A former channel of the Fraser River is cut by the river at the lower end of the Fort George Canyon and the filling is exposed for a distance of upwards of half a mile between that point and the mouth of Redrock Creek, and over a vertical height of about 200 feet.

The following section is here afforded: at the top, underlying soil and timber growth, silt, 3 feet; post-glacial gravel 3 to 7 feet; varved clay, 25 feet; boulder-clay, 5 feet; cross-bedded glacial gravel, 30 feet; boulder-clay and glacial gravel, 25 feet; well-sorted river-gravel, not very tightly compacted, 80 feet extending to river-level. Some of the varves of the boulder-clay are curved indicating slumping subsequent to deposition.

The river-gravel in this exposure may represent the restoration of flow of the Fraser River subsequent to damming by the Upper Volcanics, and may therefore be of Pliocene age, although it is also possible that the gravel is of interglacial age. Insufficient criteria make the matter indeterminate. Lack of any high degree of compacting does not, however, necessarily disprove Tertiary age. In the channel exposed on the north side of Baker Creek, the sediments underlying pillow-lava of the Upper Volcanics, are loose.

(c) On the east bank of the Fraser River directly opposite South Fort George. The east bank rises steeply at this point to a height of 355 feet above the river. The following section is afforded: At the top overlain by soil, vegetation and timber-growth, varved clay, 12 feet; silt, 15 feet; obscurity caused by sloughed material, 62 feet; interstratified, fairly well compacted beds of fine gravel and sand with one small bed of compacted clay 6 inches thick, 146 feet; obscurity to river-level, 120 feet, due to sloughed material and vegetation. The beds of sand and gravel are horizontal. The pebbles in the gravel beds range from 1/2-inch to 3 inches in diameter and imbrication indicates a southerly flowing stream.

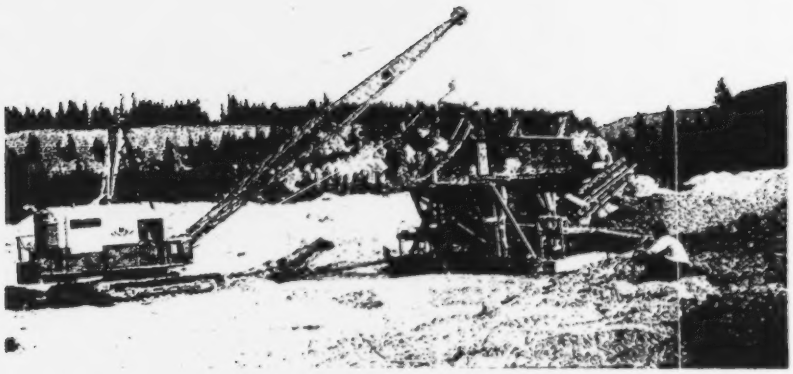


Plate II A. Drag-line dredge of the North American Goldfields Ltd., Fraser River 1 1/2 miles upstream from Alexandria Ferry.

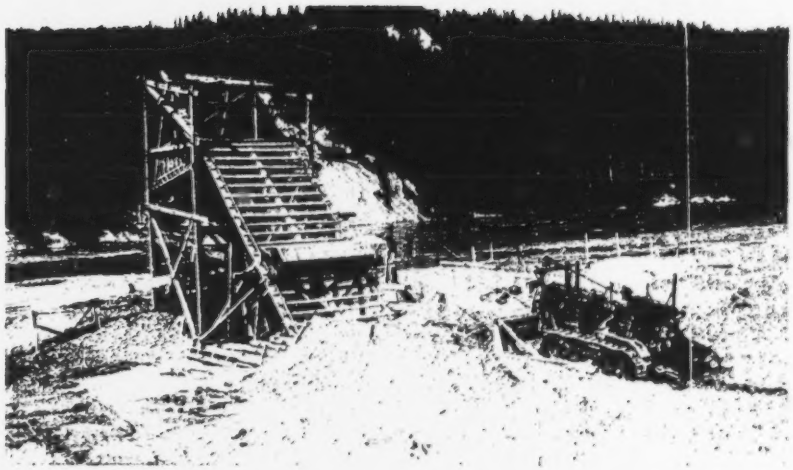


Plate II B. Placer operation of H. Craig, Fraser River 2 miles south of Quesnel.

About 200 yards down-stream from the described exposure a small creek has cut a deep incision in the deposit, and clearly reveals that the sand and gravel beds are directly overlain by boulder-clay. The following section is exposed above the beds of sand and gravel: at the top, underlying soil, vegetation and timber-growth, varved clay, 10 feet; silt, 20 feet; boulder-clay, 25 feet; glacial gravel, 15 feet; sandy boulder-clay, 50 feet; horizontally stratified beds of sand and fine gravel, 5 feet to obscurity due to sloughed material and vegetation.

It seems likely that the beds of sand and gravel are of Pliocene age representing gradual restoration of flow after damming of the Fraser River down-stream by the Upper Volcanics. It is also possible that the age of these beds is interglacial; criteria are insufficient to determine age with certainty.

(d) On the Nechako River, directly north of Prince George, the northern bank rises steeply to a height of 345 feet above the river, affording the following section: at the top overlain by 3 feet of soil and timber-growth; sandy limy silt, 35 feet; boulder-clay, 20 feet; thinly-bedded horizontally-stratified sand, containing small pieces of lignite, with some fine gravel beds, 60 feet; beds of fine sand, 10 feet; obscurity to river-level due to sloughed material. Criteria are insufficient to determine whether the beds of sand and gravel underlying the boulder-clay are of Pliocene or interglacial age.

TERTIARY WEST ROAD (BLACKWATER) RIVER SEDIMENTS

These sediments are exposed on the Fraser River at several points between the mouth of the West Road River and Whites Landing. They are of distinctive character because the large proportion of pebbles composed of grey-black quartzite are somewhat iron-stained and differ greatly in appearance from Tertiary Fraser River sediments. The distribution of the West Road River sediments in the Fraser River Valley, in this region proves conclusively that the drainage in the former river has been reversed between the mouth of the Tertiary West Road River and Whites Landing. As these sediments underlie those of the inter-volcanic Fraser River near Whites Landing, and commingle with the latter in exposures close to this point, it is clear that reversal was effected after the waters of the Fraser River abandoned their inter-volcanic channel.

The largest exposure of sediments of the Tertiary West Road River is half a mile up-stream from the mouth of the present river. The southern end of the outcrop is at the western edge of the Fraser River, but the distance of the exposure from the river increases to the north. Immediately north of the mouth of the West Road River, a rock-rim composed mainly of schistose quartzite, rises sharply from the Fraser River to a height of 450 feet for a distance of half a mile. The southern end of the exposure of sediments of the Tertiary West Road River commences at the northern end of this rim. The rim sloping at from 15 to 20 degrees with overlying sediments is exposed for 25 feet. Although somewhat obscured by vegetation, the sediments are exposed for a further 870 feet to the north-west. The average height of exposure is about 40 feet, and the base is about 25 feet above the level of the Fraser River. The sediments are directly overlain by soil and consist of horizontally-stratified beds of fine and coarse gravel, grit and sand. They are tightly compacted, the weathered face being almost vertical. The beds show considerable iron-stain. Although the relative thickness of the gravel, and sand beds vary from point to point, the following section is typical: At the top, soil, 2 feet; fine gravel, (pebbles range from 1/2-inch to 3 inches in diameter), 6 feet; sand, 3 feet; coarse gravel (pebbles range from 2 to 6 inches in diameter), 15 feet; talus slope, 8 feet; fine gravel (pebbles range from 1/2-inch to 2 inches in diameter) with coarse angular pieces of talus in size about 1 foot by 1 1/2 feet at the top, 12 feet.

Imbrication of the gravel indicates a northerly flow of water in which they were deposited. About 60 per cent. of the pebbles are composed of grey-black quartzite. About 10 per cent. of pebbles are composed of batholithic rock and volcanic rocks. Quartz pebbles possibly amount to 2 per cent. of the total. A few pebbles of highly-decomposed basalt are present.

No opinion can be formed as to the depth at which the bed-rock of this channel lies. In recent years Andrew Stewart sank two shafts to depths of 40 and 70 feet respectively in an attempt to reach bed-rock and although water was not apparently encountered the shafts were discontinued. The ladders have been removed and they are not now accessible. The shaft sunk to a depth of 40 feet is at the northern end of the exposure, about 1000 feet from the Fraser River, and the bottom is about 20 feet below the river. The other shaft is 140 feet north 59 degrees west from the first and the collar is 45 feet above it.

On the east bank of the Fraser River, about 2 1/2 miles above the mouth of the West Road River, the Tertiary sediments are exposed over a length of 500 feet and height of 35 feet. There is little if any glacial overlie, the sediments being directly covered with soil and vegetation. The top of the exposure is 100 feet above the Fraser River. The general character of the exposure of alternating beds of gravel and sand is very similar to that previously described. The imbrication of the pebbles indicates a northerly flow of the water in which they were deposited.

About 3 1/2 miles up-stream from the last-mentioned exposure on the same side of the river, 6 feet above water-level a bed or iron-stained imbricated gravel 4 feet thick, closely resembles in appearance and composition of pebbles, the Tertiary sediments of the West Road River. The length of this exposure is 75 feet, imbrication indicates an easterly flow of water. Overlying this bed is another gravel-bed 4 feet thick also, somewhat iron-stained, but pebbles show westerly imbrication. This latter is overlain by a total thickness of 8 feet of post-glacial gravel and silt.

On the northern bank of the Fraser River, 5 miles down-stream from the mouth of Whiteslanding Creek, 75 feet above river-level, sediments of the Tertiary West Road River are exposed at three points in a distance of 150 feet. The largest individual exposure is 25 feet long and 10 feet high. The exposures consist of beds of somewhat iron-stained sand and gravel and the imbrication indicates an easterly flow of the water in which they were deposited.

An exposure of Tertiary West Road River sediments underlying sediments of the inter-volcanic Fraser River on the northern bank of the Fraser River a short distance below Whiteslanding Creek has been described under "Tertiary Fraser River Sediments."

TERTIARY LACUSTRINE DEPOSITS

Deposits of lacustrine type, believed to be of Tertiary age, occur at the following points:

(1) Near Prince George on the delta-like area near the mouth of the Nechako River.

(2) On both banks of the Fraser River near Tabor Creek where the deposit is somewhat over 100 feet in exposed thickness.

(3) As a valley-flooring in the valleys of Government, Hixon and Terry Creeks, (from remnants left on the valley-rims it is evident that stream erosion has removed a considerable thickness of the original deposit).

In all cases save the first-mentioned, the deposits form a false bed-rock on which important concentrations of placer-gold occur in overlying post-glacial gravel.

These deposits differ greatly from those lacustrine deposits of Pleistocene age, which occur at many points close to the Fraser River, and which were caused by damming due to deposition of glacial debris.

No fossils were found in any of these deposits, and in some cases the overlying material is of post-glacial age. Determination of age must rest upon the features presented by the deposit itself studied in conjunction with the known damming of the Fraser River by lava in Tertiary time and its possible effect in originating deposits of this type. In other cases Tertiary age is indicated by a heavy overlie of glacial material. In some cases this type of deposit is underlain, in others overlain by a deposit of apparently tumultuous type. Such association of two radically different types of deposit can be explained by the reasonable assumption that at times the river suddenly broke through lava-dams, causing a rapid fall of water-level in the lake first formed.

(1) Exposures near Prince George on the Prince George-Hazelton highway occur (a) at a point 1 1/2 miles southerly from the town at the southern base and on the south-western slope of the more southerly knoll mentioned under "Topography" and (b) distant 1 1/4 miles to the south of (a) on the highway at the point where the latter ascends the southern rim of the Nechako River Valley. (Fig. 4). (a) At the southern base of the more southerly knoll on the eastern side of the highway, compacted greenish-coloured beds of clay-grit and sand overlie conformably

gravels containing angular and sub-angular pebbles which range from 3 to 6 inches in diameter. These beds strike north 32 degrees east and dip about 35 degrees south-eastward. The pebbles of the gravel-beds are composed of schistose rocks similar to those exposed at points to the north in the southern rim of the Nechako River Valley, with a preponderance of schistose argillite. The combined total thickness of these beds varies from 10 to 20 feet, and they are unconformably overlain by horizontally-stratified post-glacial gravels 30 feet in thickness on which rest sand beds 3 feet in thickness capped by 2 feet of soil and vegetation. The face of the exposure is nearly vertical, and the total length is 475 feet. It forms the southern bank of the "Hudson Bay Slough" at this point. Distant 400 feet southerly from the last exposure, and 60 feet higher in elevation on the south-western slopes of the same knoll on the east side of the highway, a maximum exposed thickness of 20 feet of beds of angular and rounded deeply-kaolinized granitic pebbles ranging in diameter from 6 to 10 inches are conformably overlain by a maximum exposed thickness of 12 feet of gravel consisting of angular and sub-angular pebbles of chiefly schistose argillite. This exposure, 60 feet long and of maximum height 35 feet, is directly overlain by soil and vegetation. The beds strike north 32 degrees east and dip 35 degrees south-eastward. (b) About 1 1/4 miles from the last exposure the highway ascends the southern rim of the Nechako River Valley. At this point greenish-coloured clay-grit beds underlie the road-surface, but their attitude is not apparent. About 350 yards farther south on the east side of the highway, at a point about 110 feet higher in elevation, is exposed a bank 60 feet long and 25 feet high consisting of coarse angular and sub-angular pebbles and boulders of the same rocks as those found at points to the north on the southern rim of the Nechako River Valley. This exposure is directly overlain by soil and vegetation. The pebbles and boulders of average diameter about 10 inches are deeply-rotted. This deposit also outcrops at several points in a distance of 200 yards in a bank to the south-east of this point, and apparently underlies a considerable area. The attitude is indeterminate. In the case of exposures described at points (a) and (b) the angular and sub-angular rotted gravels resemble those laid down by a torrential stream flowing for a short period, and in both cases they overlie deposits which are obviously lacustrine. The inclination of the strata may be due to slumping rather than to tectonic movement after deposition, but it is obvious that the deep rotting and kaolinization of the constituent pebbles must have taken place after deposition, and for this reason a Tertiary age is inferred because the constituent pebbles of Pleistocene deposits are seldom weathered to such a degree.

(2) On both sides of the Fraser River near the mouth of Tabor Creek.

In this region on the east side of the river and on an average of 100 feet above it, a lacustrine deposit is exposed almost continuously for a length of 2 miles from 1 mile above to 1 mile below Tabor Creek. On the west side of the river, directly opposite, the deposit is exposed in three places in a length of 1 1/4 miles from a point opposite 1 mile above Tabor Creek. The largest exposure is opposite Tabor Creek, which, with the overlie, rises steeply from the river for a length of several hundred feet and reaches a height of 235 feet above the river. Other exposures on this side are much smaller.

The character of the deposit differs somewhat on the two sides of the river. On the east side, it consists of somewhat over 100 feet of interstratified beds of arkosic grits, gritty clays, and gravel with pebbles ranging from 1/2 inch to 2 inches in diameter. These beds are horizontal, and are overlain by 1 foot to 14 feet of post-glacial gravel with numerous large boulders, and underlain at river-level by greenish-coloured clay beds. The post-glacial gravels contain an important concentration of placer-gold.

On the west bank of the Fraser River opposite a point 1 mile north of Tabor Creek horizontally-stratified beds of arkosic grit and clayey grit, of a total thickness of 65 feet, extending along the river's edge for a distance of 125 feet, are overlain by 4 feet of post-glacial gravels. Immediately down-stream from this point these beds are unconformably underlain by greenish-coloured well-lithified beds of clay, strike north 47 degrees west, dip 25 degrees south-westward. Directly opposite Tabor Creek on the west side of the river, a thickness of 110 feet of well-lithified greenish-coloured clayey grit beds is overlain unconformably by 75 feet of cross-bedded glacial gravel. The latter is overlain by a considerable amount of silt, which apparently reaches a depth of 40 feet at one point. A thickness of 10 feet of varved clay is overlain by shallow post-glacial gravel and silt at the top of the bank. The total height of this bank is 235 feet, and although the face is obscured somewhat by sloughing, the order of succession and thickness of the various beds are approximately as given above. The greenish-coloured clayey grit beds dip about 25 degrees or more westward, but the exact dip and strike are obscured by sloughing.

On the east side of the river the discharge from the sluice-flume in placer-mining operations has thoroughly washed the near-vertical face of the deposit at several points down-stream from Tabor Creek, and exposures are particularly clear. The following section at a point three-eights of a mile below Tabor Creek is typical, (except for the thickness of post-glacial gravel which varies from point to point); at the top, overlain by a few inches of soil and vegetation, post-glacial auriferous gravel, 1 foot; alternating thin beds of coarse and fine arkosic grit and clayey grits, 30 feet (the particles, which are angular or sub-angular,

in the coarser grits average about 1/4-inch in diameter); beds of rounded, and sub-angular gravel, 25 feet (some pebbles reach 2 inches in diameter, the average size is about 1 inch in diameter but a few granitic pebbles are present up to 15 inches in diameter, with lenses of clayey grits); fine grit beds interstratified with beds of clayey grits, 37 feet (large pieces of lignitized drift-wood occur in the lowest 10 feet of these beds); oxidized arkosic grits, extending to river-level 20 feet. At river-level beds of greenish-coloured gritty clay are exposed. The lowermost clay was probably laid down in a lake whereas the gritty material may represent shore-line deposition in the same basin.

Tabor Creek which joins the Fraser River at grade has cut down through the top of the lacustrine deposit. The farthest observed up-stream exposure of the latter (30 feet high, 25 feet long), occurs on the southern bank of the creek about half a mile above its mouth. On the northern bank of the creek near the mouth is an exposure of the lacustrine deposit, 100 feet high, and 175 feet long. A section of this follows: At the top, post-glacial gravel and silt capped with vegetation and timber-growth 3 to 10 feet; thinly-bedded slightly oxidized arkosic grits 80 feet; bluish-coloured clayey grits and clays down to creek-level, 20 feet. These beds are horizontal.

On the southern bank opposite, an exposure 75 feet long reveals a thickness of 7 feet of the lowest members of the same beds in contact with 4 feet of well-lithified greenish-coloured clay (very similar to those described on the west bank of the Fraser River opposite this point and near Prince George); overlying this exposure is 13 feet of post-glacial gravel and silt. Considerable faulting is evident in the greenish-coloured clay, which has also affected to a lesser extent the lowest members of the overlying deposit. These greenish-coloured clay beds are also exposed on the east side of the river just above water-level at several points down-stream from the mouth of Tabor Creek, and it is clear that they underlie the other deposits described on this side of the river.

These exposures indicate that after the greenish-coloured clays and the lowest beds of the overlying clayey grits were deposited they were tilted either by faulting or slumping. Then followed deposition of the overlying horizontal beds of clayey grits, gravel and arkosic grit. The attitude of which indicates the absence of movement subsequent to their deposition. Their character coupled with presence of pieces of carbonized driftwood, demonstrates that lacustrine conditions alternated with those of sluggish flow of water. On the east side of the river post-glacial erosion has entirely removed any once existent overlying glacial deposits such as those on the west side of the river, and the lacustrine deposit is directly overlain by auriferous gravel

containing numerous boulders, many of large size (the dimensions of the largest observed boulder were 5 1/2 by 3 1/2 by 3 1/2 feet. The depth of the overlying post-glacial gravel varies from 1 foot to a maximum of 14 feet. An important concentration of placer gold has been laid down on top of the impervious lacustrine deposit.

A careful examination of the boulders was made in order to determine their source, and the matter is further discussed subsequently under "Placer-gold Deposits." Possibly there has been a commingling of drift from several sources (a) From the north-west by an ice-sheet which moved south-easterly (b) From the north-east by an ice-sheet moving south-westerly from the Rocky Mountains.

Field observations indicate that the general features of this deposit are radically different from those of Pleistocene lacustrine deposits and more nearly resemble those of Tertiary age. It appears to trend in a north-westerly direction, and the underlying tilted greenish-coloured clay beds are similar to those previously described near Prince George. Both deposits may have been laid down in the same lake or in two closely-adjoining lakes.

(3) *On Government Creek.* Placer deposits on this creek occur on a false bed-rock formed by a deposit of lacustrine type with which apparently the valley is floored for a distance of about one mile above the canyon.

The thickness of this deposit is unknown and the only information now available concerning it, is from exposures only a few feet high at wide-separated points on the banks of the creek and from shallow shafts sunk in it at various points, some of which have now caved. About 1 mile above the canyon, the low-lying benches on the creek are underlain by compacted thinly-bedded clay-silt. The latter, as shown by the dump at the collar of a shallow shaft now full of water, is apparently underlain by angular and sub-angular pieces of quartz ranging from 1/2 inch to 2 inches in diameter mixed with angular and sub-angular pieces of schistose rocks of about the same size. Similar rocks occur in place within the valley at up-stream points.

Near the head of the canyon on each side of the creek, within 10 feet of the water's edge, four shafts have been sunk opposite each other at intervals of between 35 and 40 feet, on small low-lying benches which flank the creek at this point. As the creek flows over bed-rock quite possibly bed-rock was reached in all of the shafts. Those on the west side of the creek are filled with water, to within 10 feet of the collar. The material passed through in each case consisted of thinly-bedded tight sand, clay, and fine angular and sub-angular material with some quartz. Much

the same material was encountered in the shafts on the east bank of the creek, as far as can be judged from their sloughed condition, save that in the most southerly, below the lacustrine beds, a bed of coarse sub-angular quartz pebbles was cut. This bed is directly underlain by bed-rock. The quartz pebbles range from 6 to 10 inches in diameter.

(4) On Hixon Creek. Exposures of deposits of lacustrine type occur on Placer-mining Lease No. 2118, held by E. Hann and J. Strbac, about 1 1/4 miles from the old camp of Quesnelle Quartz Mining Company Limited.

A branch-road 4 1/2 miles long, leaves the Prince George-Quesnel highway, a short distance north of Canyon Creek, and leads to the property of Quesnelle Quartz Mining Company, Limited. From this point the property is best reached by following the wagon road to Little Hixon Creek, and thence along the flume-grade of Hixon Quesnelle Placers, Limited, on the north side of Hixon Creek.

Hixon Creek in this region flows north-westerly and westerly. The placer-workings of the form of a shallow hydraulic pit of maximum depth 20 feet, are on the south side of the creek, and extend for 450 feet along it, and to a maximum distance of 375 feet south of the creek. These workings follow bouldery post-glacial gravel, several feet thick, which overlies a false bed-rock, described below, at or near creek-level. The post-glacial gravel contains coarse placer-gold of residual character. The elevation of the floor of the pit, which is but little above creek-level, is 2480 feet.

Up-stream and down-stream from the hydraulic pit, schistose rocks are exposed at intervals on both sides of the creek at creek-level. Farther up-stream granitic rocks are known to occur. Underlying the post-glacial gravel is a false bed-rock consisting of white clay in which are angular and rounded fragments ranging from 1/8-inch to several inches in diameter. These constituents consist of high-temperature bluish-coloured quartz, vein-quartz, schist, and granitic rock; some are extensively kaolinized. The thickness of this material is unknown. A fine-grained, thinly bedded deposit of a salmon-pink colour directly overlain with soil or shallow veneer of glacial debris, is exposed at the western edge of the hydraulic pit for a distance of 200 feet and maximum height of 20 feet. Under the hand-lens this salmon-pink coloured deposit is seen to consist of quartz and rock-particles with abundant sericitic material. Ferruginous bands up to 1-inch in width occur at several points. Underlying this deposit there appears to be a considerable amount of lignitized wood, but owing to sloughing this was not clear. This lignitized wood presumably occurs at some points between the salmon-pink deposit and the kaolinized false bed-

rock, but at others the salmon-pink thinly-bedded deposit directly overlies the latter, according to information supplied by the owners of the lease. Some years ago two shafts were sunk in the hydraulic pit about 200 feet apart a short distance south of the creek. The more westerly one was sunk 14 feet in the salmon-pink coloured deposit bottoming in the white, kaolinized, false bed-rock. The other shaft was sunk it is stated to a depth of 37 feet, and at a depth of 20 feet penetrated the white, kaolinized, false bed-rock, in which the shaft was continued for the remaining distance.

About 1000 feet down-stream from the hydraulic pit on the opposite side of the creek is an informative exposure resulting solely from natural agencies. The bank of the creek is steep, sloping at from 35 to 40 degrees, and the following section is exposed: at the top immediately overlain by soil and vegetation boulder-clay, 35 feet: clayey silt, 2 feet; fine and coarse sand, 1 foot; arkosic grit, with rounded and angular particles of quartz and feldspar, and containing considerable mica, 6 feet (the lowest part of this bed contains some salmon-pink coloured material); thinly-bedded salmon-pink coloured deposit, identical in character with that described in the hydraulic pit, 20 feet; sloughed material 45 feet, which obscures the base of the salmon-pink coloured deposit, extends to creek-level. The attitude of all beds below the boulder-clay is horizontal. The total thickness of boulder-clay is quite likely much greater than 35 feet, as the top of the valley-rim is about 100 feet above this exposure, and covered with vegetation and timber-growth. This exposure proves that the deeply oxidized salmon-pink coloured deposit is of Tertiary age, as it is altogether improbable that oxidation could have taken place subsequent to the deposition of the heavy cover apparent in the section.

The kaolinized white fragmental material which underlies the salmon-pink coloured deposit, save where the latter has been swept off by post-glacial waters, and which forms the false bed-rock on which a concentration of placer-gold occurs, somewhat resembles a tumultuous stream deposit. It certainly contains some placer-gold in its upper part. This gold may have been deposited with the formation or it may have originated from the overlying coarse bouldery post-glacial gravel. The post-glacial gravel contains many large pebbles and boulders of the same composition as the constituents of the kaolinized false bed-rock, and might possibly result from erosion of it by a powerful stream. Unfortunately, only the top of the false bed-rock can be examined, no section being exposed. It is possible that the salmon-pink coloured, stratified deposit and underlying white kaolinized false bed-rock occur at other points on Hixon Creek down-stream, but the deep weathering and kaolinization of rock-exposures coupled with obscurity due to vegetation leave a factor of

uncertainty. For example, about half a mile down-stream from the hydraulic pit on the northern bank of the creek, a shaft was sunk in 1927 to a depth of 50 feet in a salmon-pink coloured deposit, and at this depth is reported to have penetrated auriferous white kaolinized fragmental material.

(5) On Terry Creek. On this creek concentrations of placer-gold occur at different points of the creek in post-glacial gravel a few feet thick overlying a false bed-rock of kaolinized granitic material which contains many large rounded boulders of quartz. At the date of examination on September 14th Archie Stewart and associates at a point about 1 1/2 miles above the mouth of the creek were engaged in shovelling post-glacial gravel, overlying the kaolinized granitic material, into a sluice-flume. The post-glacial gravels here are several feet thick and form the low-lying banks of the creek. Discovery of a three-ounce gold nugget was reported in 1940 by Stewart.

Just below the junction of Tom Creek, a small tributary flowing northerly into Terry Creek 4 miles above its mouth, on the steep southern bank of Terry Creek, a particularly informative section is afforded: at the top, overlain by vegetation and timber-growth, boulder-clay and glacial gravel, 50 feet; red-stained sand and gravel (stated to contain some placer-gold) 25 feet; stratified clay, 5 feet; boulder-clay, 35 feet; kaolinized material consisting of sub-angular and rounded boulders of quartz, quartz-feldspar (some 2 or more feet in diameter), and granitic rock, 35 feet, extending to creek-level.

A short distance up-stream, from this point on the same side of the creek, immediately above Tom Creek, the following section is exposed; at the top overlain by vegetation and timber-growth, boulder-clay 30 feet; kaolinized fragmental granitic material with large boulders, 25 feet. The fragmental granitic material overlies greenish-coloured clay beds at creek-level. The greenish-coloured clay is similar to that described as occurring near Prince George, and on the Fraser River near Tabor Creek. The kaolinized fragmental granitic material has points of resemblance to the white kaolinized material described on Hixon Creek. The exposures on Terry Creek prove the Tertiary age of the kaolinized fragmental granitic material and of the underlying greenish-coloured clay. The former appears to be a tumultuous stream deposit and the latter is of lacustrine origin. The exposure of two sheets of boulder-clay separated by the red-coloured sand and gravel beds is of interest as proving two advances of ice. The interglacial age of the slightly auriferous red-stained sand and gravel beds is also clearly indicated. It is possible that the placer deposits on this part of the creek result in part from the re-sorting of the red sand and gravel by post-glacial waters.

PLACER-GOLD DEPOSITS

LEASES OF THE ROBERTSON BROTHERS

Five placer-mining leases held by the Robertson Brothers, of Prince George, are on the east bank of the Fraser River immediately to the south of Tabor Creek. In 1940 N. G. Thomas held a working agreement on this ground.

The property is reached by a branch motor-road, 4.2 miles in length, which leaves the Prince George-Quesnel highway immediately south of the Tabor Creek crossing 13 miles south of Prince George. The road leads almost due west across to the western edge of the plateau, then crossing the Pacific Great Eastern railway-grade descends on good grade to a large bench on which the property is situated.

The property covers the greater part of a large triangular-shaped, well-timbered bench situated about 105 feet above the Fraser River. This bench having a total area of about 375 acres is bounded, on the north by the south valley-rim of Tabor Creek, on the west by the Fraser River and on the east very nearly by the Pacific Great Eastern railway-grade, save that the bench extends to the east of it in the vicinity of Tabor Creek. There are various shallow depressions in the bench due to the differential cutting of post-glacial waters such as frequently occur on large benches; chief of these depressions is one about half a mile long of a maximum depth of 25 feet, which crosses the bench obliquely to the Fraser River about a mile below the mouth of Tabor Creek.

The placer deposit is a concentration by post-glacial waters in bouldery gravel which varies from 1 foot to 14 feet in thickness and immediately overlies a false bed-rock formed by a tightly-compacted impervious lacustrine deposit (see Lacustrine Deposits) which is of unknown thickness but which is exposed at the edge of the bench for a height of 105 feet above river-level. Much of the gold is coarse and nuggety although some is fine.

The existence of this deposit has long been known and the lower part of Tabor Creek, which cuts the deposit to a depth of somewhat over 100 feet, was possibly worked by the early miners. In 1925, 8 mineral claims named Six Mile Goldfields group, were staked at this point, owing to the reported occurrence of gold values in the lacustrine deposit as distinct from the placer-gold in the overlying gravel. In 1932, Prince George Gold Mines, Limited, was incorporated and acquired both placer-mining and lode-mineral rights near the mouth of Tabor Creek, but no material activity resulted (see Annual Reports of Minister of Mines, British Columbia, 1925 and 1932).

In 1934, E. P. Caus and E. Vulson acquired three placer-

mining leases on the bench to the south of Tabor Creek, and installed a pump at river-level to deliver wash-water to the bench. They reported encouraging values, but subsequently discontinued operations.

In 1939 J. S. Robertson and Val Witt tested the bench farther to the south than previous operators, reporting good values in the region worked by N. G. Thomas in 1940. A high-lying bench such as exists at this property offers a difficulty to the small operator, if no readily available supply of water can be brought to the ground by gravity.

In 1939 N. G. Thomas brought water on the ground from the upper part of Tabor Creek, installing a flume 24 inches by 15 inches about 1 1/2 miles in length, for this purpose. N. G. Thomas stated that after sinking forty-two test-pits over an area of 50 acres, he decided to instal mechanical equipment.

The gravel was loaded by a shovel with 5/8-cubic yard bucket operated by a gasoline engine, into motor-trucks, which conveyed it to a washing-bin set up over a sluice-flume at the edge of the bench. Grizzly bars over the bin were spaced at intervals of 5 inches, and the washed oversize went to the waste dump at the river's edge, the underside passing into the sluice-flume. At the time of examination three motor-trucks were employed, conveying an estimated 3 cubic yards of gravel per load, the total maximum amount of gravel trucked in a shift of 8 hours being about 360 cubic yards.

The water-flume bringing the water supply is at the northern end of the ground, and the gravel is removed in long narrow sections from the edge of the bench easterly. The many large boulders are piled in rows parallel to the edge of the bench and so spaced that there is room for a truck-road between any two rows. At the time of examination in 1940 an area about 750 feet by 350 feet near the northern end of the bench had been mined.

The sluice-flume in use was 67 feet long, cross-sectional dimensions being 2 1/2 feet by 1 foot 4 inches. Riffles used in the first 54 feet of the flume consisted of rails laid both longitudinally and cross-wise directly on the bottom of the flume, but in the central part of the flume the rail riffles were laid on metal screening over blanket-cloth. Below the rail riffles a length of 6 feet consisted of rubber-riffled cloth. At the end of the latter was an under-current in which riffling consisted of expanded metal on blanket-cloth.

The lacustrine deposit forming the false bed-rock is quite impervious, and for this reason in wet weather, the collection of pools of water on the clayey false bed-rock either retards or

entirely prevents the operation of the motor trucks.

Although there is some fine gold, much of it is coarse and nuggety and easily recoverable; pieces up to several dollars in value, with one nugget weighing 6 dwt., were found. Occasional small nuggets of native silver and native copper are recovered.

Values are stated to vary from point to point, and although the average value per cubic yard is not known to the writer, detailed testing of a large area in this region seems warranted. It is not known if the entire bench is underlain by the lacustrine false bed-rock, but both bench and false bed-rock continue beyond the limits of this property for about 1 mile to the north of Tabor Creek. The bench continues for about 1 1/2 miles south of Tabor Creek, and the edge of the lacustrine deposit is exposed at the river to a point about 1 mile south of Tabor Creek beyond which the edge is screened with dense vegetation. The lacustrine deposit is exposed over a height of 30 feet and length of 25 feet on the southern bank of Tabor Creek about half a mile up-stream from the mouth. This is the farthest observed easterly extension of this deposit.

LEASE OF P. W. MUNRO — One placer-mining lease held by P. W. Munro of Prince George immediately adjoins the property of the Robertson Brothers on the north, and extends for half a mile up-stream from the mouth of Tabor Creek covering ground on both banks of this creek. The property is reached by a branch motor-road 400 yards long from the road leading to the property of the Robertson Brothers.

The part of the property now being worked by the owner is close to the boundary line between his property and that of the Robertson Brothers, and is the northerly continuation of the same bench. The type of placer occurrence is the same in both properties at this point.

By arrangement, P. W. Munro uses part of the water-supply from the flume and works his property by hand, shovelling the gravel into a small sluice-box. The size of the hydraulic pit at the time of examination on July 10th, was about 100 feet by 50 feet. On this ground the depth of post-glacial material overlying the lacustrine deposit forming the false bed-rock was about 4 feet, of which the lower 15 inches consisted of gravel, and the upper 33 inches of silt. The owner reports encouraging values. The character of the gold is much the same as that recovered from the Robertson leases.

LEASE OF A. DRAGE — One lease, No. 4044, it is understood adjoins that of P. W. Munro to the east. On July 10th, 1940, no sluicing operations were taking place, work to that date having comprised general prospecting.

A careful examination was made of the boulders in the auriferous gravel, and also of the gravel beds in the lacustrine deposit. It seems evident that there may be commingling of glacial drift in this region derived from several sources: (a) From the north-west by an ice-sheet moving south-easterly, (b) From the north-east by an ice-sheet moving south-westerly.

Examination of the Robertson Brothers hydraulic pit showed that about three-fifths of the boulders were composed of foliated quartzites, about one-fifth were batholithic rocks, and about one-fifth were volcanic flow rocks probably of Palaeozoic age. A few quartz boulders were observed. The largest observed boulder was 5 1/2 by 3 1/2 by 3 1/2 feet in size.

In P. W. Munro's much smaller hydraulic pit, about 40 per cent. of boulders were composed of gneissic rocks, 40 per cent. were composed of batholithic rocks, and the remainder of chiefly metamorphosed volcanic flow-rocks.

General In the post-glacial gravel are some pebbles of pyrite. Two unusual types of pebbles were observed. One type consists of a hard fine-grained core of indurated clay in which are embedded smaller pebbles about 1/2-inch to 1 inch in diameter. The derivation of this type was found in the course of examination of the Fraser River at up-stream points. As previously explained, deposits of varved clay occur at a number of points overlying the glacial deposits. A piece of clay breaking away rolls down the talus slope below the varved clay and in its passage small pebbles become embedded in it. Many of these pebbles become baked hard in the sun to be subsequently transported down-stream by a rise of the river. Another type of pebble consists of a white clay interior in which is a small piece of lignite, with a hard shell exterior formed of ferric oxide. These are also probably derived from varved clay containing vegetable matter, which has been baked in the sun, and subsequently been impregnated with surface waters containing iron in solution. The reducing action of the lignite decolourizes the clay in its vicinity.

Stocks of batholithic rock of considerable size occur (see "Bed-rock Geology") both to the north-west on the southern rim of the Nechako River Valley near Prince George, and also to the north-east near Eaglet Lake. Smaller stocks of batholithic rock are found on the mountain known locally as "Six-Mile Mountain" east of Tabor Lake. Metamorphosed volcanic flow-rocks outcrop both to the north-west and to the north-east of this region. Gneissic rocks occur in greatest abundance to the north-east at the north point of the Fraser River, although some are seen to the north-west.

A number of cupriferous quartz veins occur on "Six-Mile Mountain" and adjacent region, and the placer deposits, on Skaret Creek also in this region, doubtless have a local source.

Quartz veins also occur west of Prince George on the southern rim of the Nechako River Valley and also in an area 5 miles south-westerly from Prince George.

The lacustrine deposit itself was sampled at the eastern part of the bench immediately east of Tabor Creek, where the overlying post-glacial gravel was known to have been particularly productive. At this point the upper beds consist of arkosic grit. A sample of a vertical section 10 feet high, the top of which was 4 feet below the top of the lacustrine deposit, assayed: Gold, nil. Another sample of the same section weighing 15 pounds was carefully panned, yielding pannings weighing one ounce. This assayed: Gold, trace; sulphur, trace.

As explained under "Lacustrine Deposits" in this report, the interstratification of beds of gravel containing rounded and sub-angular pebbles with clay and grit beds in the lacustrine deposit, indicates that lacustrine conditions alternated with those of sluggish flow. Six pebbles taken at random from a gravel bed 8 feet thick 40 feet below the top of the deposit below the placer workings on the Robertson Brothers leases were found to be composed of the following rocks: granodiorite, diorite, argillite (2 pebbles), schistose rock, chloritized andesite. These rocks are known to outcrop to the west of Prince George, on the southern rim of the Nechako River Valley near which is also another lacustrine deposit. Although the deposit near Tabor Creek appears to trend in the direction of the latter, it cannot be assumed that both are parts of the same deposit as the distance between the exposures is about 5 miles.

The precise origin of the placer gold in the Tabor Creek deposits is not easy to determine. The region at the headwaters of Tabor Creek is capable of supplying the metals found, namely native silver, native copper and gold and perhaps is the most likely source. The presence of the two former, and the coarse gold indicates an origin in Tertiary time through the operation of processes of secondary enrichment. Assuming a tumultuous run-off of water during the early stages of ice-advance, it is conceivable that the material containing the detrital metals might have been borne to its present position to be subsequently re-sorted by post-glacial waters. Another tenable view is that this material was ice-borne from its source to its present position and subsequently re-sorted. In this connection on the west bank of the Fraser River at the Fort George Canyon, where the rocks afford no evidence of a local source of gold, post-glacial gravels overlie rock-benches, and in the aggregate are probably not very rich, the gold is of coarse character, one nugget weighing 3 ounces being recovered some years ago (refer to Annual Report, Minister of Mines, British Columbia, 1935, pp. C21 and C22).

A less likely view is that the placer-gold originates from a stream-eroded part of the lacustrine deposit. Justification for such a view may perhaps be found in deposits of a tumultuous character apparently auriferous overlying lacustrine deposits such as are described on Hixon and Terry Creeks.

REVIEW OF DRAINAGE-HISTORY

As stated in British Columbia Department of Mines Bulletin No. 3, 1940, it is postulated that in late Cretaceous time a pre-volcanic Fraser River and tributaries flowed northerly north of the Chilcotin River. The evidence in support of this, although strong, is indirect. This northerly drainage was ultimately into the Cretaceous basin which covered the region now occupied by the Great Plains and extended to the side of the Rocky Mountains.

Whether this northerly drainage was entirely tributary to the ancestral Peace River or not, must be deemed in a measure conjectural in view of the immense time-interval which has elapsed. There is, however, a sub-stratum of fact which removes much from the realm of conjecture. An examination of these facts supports the view that the major part of the northerly drainage may have been tributary to a then northeasterly-flowing Herrick-McGregor River, a minor part only draining to the Peace River, for the following reasons:

(a) The size of the valley containing the Herrick-McGregor River; its low gradient and extent for about 50 miles in a north-easterly direction on the northern side of the Rocky Mountain Trench, are features suggesting that the flow of the river was originally north-easterly.

(b) The presence of a stock in the northern wall of the Rocky Mountain Trench to the south-east of the McGregor River suggests the possible pre-Laramide age of the Trench and possibly two parallel trenches to the north at this point. Inasmuch as commencement of a trellis-type of drainage and deepening of the trenches would at once follow origination of these parallel mountain-structures, this suggests that the Herrick-McGregor drainage antedates the Laramide revolution.

(c) The presence of the Eaglet Lake - Aleza Lake - Hansard Lake Valley extending to the west virtually in line with the Herrick-McGregor Valley, and the position of both valleys at the northern ends of the six parallel, closely-spaced northwesterly-trending mountain ranges, suggests that the same northeasterly-flowing river may have occupied both the valleys. The subsequent reversal of drainage has doubtless caused the mouth of the McGregor River to shift somewhat to the north of its original position.

(d) The fact that the Crooked-Pack River Valley gets shallower to the south and finally merges in the Nechako Plateau at Summit Lake may signify that the source of these rivers was never far south of this point. The drift-covered Nechako Plateau between Prince George and Summit Lake is to a great extent topo-

graphically featureless, save for the valley of the Salmon River, and affords no evidence of any former northerly-flowing water-course south of Summit Lake.

It, therefore, seems a rational hypothesis that the northerly drainage of the Fraser River joined by the Nechako and Salmon Rivers near Shelley was by way of the Eaglet Lake - Aleza Lake - Hansard Lake Valley to the then northeasterly-flowing Herrick-McGregor River. A conspicuous valley now occupied by Tabor Lake and Tsadestsa Creek trends north-easterly between Tabor Lake and the Willow River Valley. This valley may have been occupied by the northerly-flowing Fraser River up-stream from the Eaglet Lake - Aleza Lake - Hansard Lake Valley. The latter is of more mature relief and appears to be older than that occupied by the Fraser River at its most northerly point, and when it was occupied by the north-easterly drainage there was, presumably, no through-valley where the great bend of the Fraser River now is. Tay Creek probably represents the headwaters of a then southeasterly-flowing tributary of the drainage via the Herrick-McGregor Valley. There was also at this time probably a northwesterly-flowing tributary drainage occupying the Rocky Mountain Trench for some distance above the mouth of the Herrick-McGregor River. Subsequently, following the Laramide revolution and the uplift of the land surface the rapid headward erosion of the then southerly-flowing Fraser River being somewhat to the west of the northerly drainage, caused abandonment of the Eaglet Lake - Aleza Lake - Hansard Lake Valley, much stream-reversal and, the adoption of the valley now followed. The fact that the southerly-flowing pre-volcanic Fraser River followed a course somewhat to the west of that of the northerly-flowing river may perhaps be explained by the fact that the western slope of the pre-existent mountain-structures which trend north or north-west would be calculated to have such effect.

The fact that there are two exposures of sediments of the inter-volcanic Fraser River in the great bend of the river at its most northerly point, proves the adoption of this valley in pre-Miocene time.

The Willow River being imprisoned in a trench was thus independent of the remaining northerly Fraser River drainage, and may have continued to flow through the Eaglet Lake - Aleza Lake - Hansard Lake Valley for some considerable time after reversal of the remaining Fraser River northerly drainage. This may account for the erosion of the Eaglet Lake - Aleza Lake - Hansard Lake Valley to somewhat greater depth than the Tabor Lake - Tsadestsa Creek Valley. The Willow River was presumably captured by a then westerly and north-westerly flowing tributary of the southerly-flowing Fraser River. These tributaries coincided in direction with Hay Creek and the lower few miles of the Willow River.

It will be noted that the Bowron River makes an abrupt easterly turn and for the last 15 miles of its length flows approximately parallel to the Eaglet Lake - Aleza Lake - Hansard Lake Valley.

It is probable that capture of its headwaters by the pre-volcanic southerly-flowing Fraser River would deprive the Herrick-McGregor River of power to hold its own against the slowly-rising Rocky Mountains, whereas the Peace River supplied by powerful tributaries retained a sufficient volume of water to hold its course against the slow mountain-building.

It is unfortunate that palaeontological evidence of age is lacking in the case of the pre-volcanic exposures of river-sediments to the north-east of Shelley, and also unfortunate that a section is not exposed nearer bed-rock because of the information it would yield as to the terrain eroded. The significance of this exposure has been previously discussed in detail under "Tertiary Fraser River Sediments."

The depth of entrenchment at this point suggests that it may be an exposure of a southerly-flowing river.

To the south the northerly-flowing Fraser River appears to have occupied the channel extending northward from Soda Creek on the east side of the Fraser River to the mouth of Canyon Creek (Fig. 1, British Columbia Department of Mines Bulletin No. 3, 1940). Although evidence on this point is meagre, it is significant that there is a gap in the bed-rock on the Cottonwood River, 1 1/2 miles wide, in line with Dragon and Ten Mile Lakes. Elsewhere the Cottonwood River is wholly contained in a rock canyon in this region. North of Ten Mile Lake, the northerly-flowing river must have occupied the same valley as the pre-volcanic southerly-flowing Fraser River, which, save for a short coincidence north of Whites Landing, again joins the Fraser River Valley near the south end of Woodpecker Island.

Schofield in "The Origin of the Rocky Mountain Trench, B.C.," Proceedings and Transactions of the Royal Society of Canada, Third Series, Volume XIV, Section IV, 1920, considers that the proto-Kootenay River eroding headward captured the Nechako-Salmon-Fraser Rivers draining into the Peace River, and that these headwaters of the proto-Kootenay River were subsequently captured by the southerly-flowing Fraser River.

The damming of the southerly-flowing Fraser River by the eruption of the Lower Lavas is discussed in detail in British Columbia Department of Mines Bulletin No. 3, 1940. Evidence was found during the field-work of 1940 that the Chilako and Nechako Rivers were also dammed by these lavas.

The height to which the Fraser River rose as a result of damming by the Lower Lavas and the consequent depth of the basins formed in which Australian members (a) of the Fraser River formation (the coal series) were deposited, is well illustrated at "Rich Bar" 4 miles down-stream from Quesnel on the east bank of the Fraser River. There a bench about 15 feet above river-level, between 250 and 300 feet wide, flanks the east bank of the Fraser River for a length of about half a mile. At the back of this bench the valley-rim rises steeply to a height of 500 feet above the river and appears to consist largely of Australian members (a) of the Fraser River formation. The latter also floor the bench and form the bed-rock of the post-glacial deposits of placer-gold at this point. The old workings cover a large part of the area of this bench.

During 1940 at several different points exposures of coarse river-gravel were found conformably overlying Australian members (a) of the Fraser River formation. These are described under "Tertiary Fraser River Sediments," and prove that in these instances flow of the Fraser River was restored directly over the basins in which the deposits of lignite were formed, doubtless as the river cut through lava dams. They are somewhat younger than the sediments of the intra-Lower Lavas Fraser River, but to avoid undue complexity they have not been classified separately.

Following deposition of Australian members (a) of the Fraser River formation, orogenic movement took place and the formation was folded.

Exposures of the inter-volcanic Fraser River prove that the life of this river was long, its headwaters extending at any rate as far as Tete Jaune, and its channel was incised to or below the present level of the Fraser River. A very large amount of erosion was accomplished by it.

Eruption of the Upper Volcanics with consequent damming again caused the waters of the Fraser River to rise to a great height, as shown by exposures of the sediments of the intra-upper Volcanics Fraser River close to the top of the present Fraser Valley-rims. As a result of this damming, lacustrine deposits were formed in tributary valleys, and also in the Fraser River Valley near Tabor Creek. These deposits are described in detail under "Tertiary Lacustrine Deposits."

Possibly due, indirectly, to damming by the Upper Volcanics down-stream, the Fraser River at this time abandoned its former valley, largely filled with an accumulation of sediments, between Whites Landing and the mouth of the Cottonwood River, and incised a new valley between the mouth of the Tertiary west Road River and the Cottonwood Canyon, of which the Tertiary Mine channel is

probably the down-stream end. Drainage in the Tertiary West Road River was reversed between the former mouth of this river and Whites Landing. There was thus formed a detour around the old valley, which the river again entered near the mouth of the Cottonwood River.

The pre-volcanic southerly-flowing Fraser River probably followed the present Fraser River Valley as far as the south end of Woodpecker Island, although there are no exposures of its sediments in this part of the river. Its occupancy of the now largely-filled and abandoned valley between Woodpecker Island and the mouth of the Cottonwood River is proved by an exposure of its sediments on Canyon Creek and also by the presence of Australian members (a) of the Fraser River formation on Canyon Creek, as the latter were the result of the damming of this river by the eruption of the Lower Lavas.

The position of this ancient valley is described under "Topography" and "Bed-rock Geology." From Woodpecker Island to a point a short distance below the mouth of Canyon Creek, the Fraser River flows just outside the west rim of this ancient valley and occupies the western side of this valley for the remaining short distance to Whites Landing. At this point the river makes a wide detour to the west flowing westerly, south-westerly and south-easterly to cut through the west rock-rim of the ancient valley and re-enter it just above the mouth of the Cottonwood River. This ancient valley was occupied apparently not only by the northerly-flowing Fraser River but also by the southerly-flowing pre-volcanic and subsequent Tertiary Fraser Rivers up to and including the inter-volcanic Fraser River. The latter appears to have occupied a position within it somewhat to the west of the pre-volcanic Fraser River doubtless owing to accumulation of sediments in the eastern part. At this time the West Road River joined the inter-volcanic Fraser River at Whites Landing. That part of the Fraser River Valley between the mouth of the Tertiary West Road River (half a mile above the present mouth of this river) and the mouth of the Cottonwood River was non-existent.

The several exposures of Tertiary gravels of the West Road River between its mouth and Whites Landing clearly prove that this part of the bend is the down-stream part of the Tertiary West Road River, which formerly joined the Fraser River at Whites Landing, and that drainage in this part of the river has been reversed. An exposure of the Tertiary West Road River gravels is overlain at Whites Landing by gravel of the inter-volcanic Fraser River. The respective gravels of these Tertiary rivers are of quite distinctive types, but there is a certain amount of commingling of the two types in the several exposures near Whites Landing. Exposures of the inter-volcanic Fraser River indicate that at the end of its life, owing to heavy over-loading, the

bed of this river had become largely filled with gravel and sand. When, therefore, the subsequent Fraser River (the intra-Upper Volcanics Fraser River) was dammed down-stream by the eruption of the Upper Volcanics, the waters probably overflowed the then-existent valley near the present mouth of the West Road River, and rejuvenation was effected from this point down-stream to the Cottonwood Canyon by the course followed by the present Fraser River. The Cottonwood Canyon is a post-glacial and Pleistocene feature, but the Tertiary Mine channel which trends parallel to the Fraser River for some distance in this region, may represent the lower end of the Tertiary rejuvenation mentioned.

Continued uplift in late Tertiary time enabled the powerful Fraser River to again rejuvenate rapidly and erode the dams caused by the eruption of the Miocene (?) Upper Volcanics. It is possible that sediments on the east bank of the Fraser River opposite south Fort George, also the buried channels lying respectively (1) immediately east of the Fort George Canyon, (2) east of the river at Alexandria Ferry, and (3) west of the river a short distance up-stream from the last-mentioned point, are all of Pliocene age, although owing to lack of criteria, it is not possible to make a definite assertion on the point, because all these may be of interglacial age. In any event they prove that deep incision had again been accomplished at any rate prior to the end of the Pleistocene epoch.

ROCKY MOUNTAIN TRENCH

Irrespective of the question of origin at different points, the form of the Rocky Mountain Trench, save in the region of the break noted in this report, is comparatively simple. The south-western wall of the trench is formed by the eastern slopes of the Selkirk Mountains, and northerly mountain groups, while the western slopes of the Rocky Mountains form the north-easterly wall of the trench. The topography in the region of the break, the length of which is about 100 miles, is described in detail under "Topography," and is radically different.

In the following table, age is based upon palaeontological evidence when such is available. All determinations of fossils were made by the Palaeontological Section, Department of Mines and Resources, Ottawa.

TABLE OF FORMATIONS

(Tentative)

Miocene	Tertiary Mine - Canyon Mine channel
	Lacustrine deposits in Fraser River Valley and tributary valleys.
	Intra-Upper Volcanics Fraser River sediments.
	Upper Volcanics, chiefly basalt flows.
Oligocene	Diatomite deposits (Members (c) of Fraser River formation).
	Flat-lying tuff beds of Horsefly area (Annual Report, Minister of Mines, British Columbia, 1938, Page C 20).
	Inter-volcanic Fraser River sediments (Members (b) of Fraser River formation).
	Unconformity
Eocene	Australian members (a) of Fraser River formation (contain pebbles of Lower Lavas, but no intrusive igneous bodies).
	Inclined tuff beds of Horsefly area with intercalated basalt flows of Lower Lavas (Annual Report, Minister of Mines, British Columbia, 1938, pp. C 19 to C 21).
	Unconformity
	Lower Lavas--dykes and sills.
	Intra-Lower Lavas Fraser River sediments.
	Lower Lavas--andesite and basalt flows.
	Unconformity
	Pre-volcanic southerly-flowing Fraser River Sediments.